EARTH LORE

A Physical Geography

BY

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A NEW EDITION
REVISED & ENLARGED

WITH 72 MAPS, ILLUSTRATIONS AND DIAGRAMS

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PREFACE TO NEW EDITION

THE new and enlarged edition of *Earth Lore* retains all the essential features of the original work, and, in addition, contains the principal chapters of Book VI (*Physical Geography*) in the Edina Geographies Series by the same author. Issued in a new form, the book presents the essentials of World Geography in a simple way based on Nature Study. It is eminently suitable for the pupils in the Lower and Middle Forms of Secondary and Central Schools, and would be a useful course in other schools, where specialisation is practised. It also meets the requirements of the University, School Leaving, College of Preceptors, and other examinations.

The subject-matter has been arranged in its logical sequence, but the teacher should follow such order as is best suited to his own requirements. The plentiful use of line diagrams should help the student to grasp the text. For the benefit of younger teachers the author has appended a scheme evolved after thirty years' practical experience in teaching the subject.

The author wishes to express his thanks to Mr. T. L. Millar, Headmaster, North Merchiston School, Edinburgh, for revising the proofs and making many valuable additions; to Mr. N. Tennant, Art Master, East Ham Technical College, for preparing line diagrams; and to Messrs. Townson & Mercer, Scientific Instrument Makers, of Camomile Street, London, E.C., for their diagrams of temperature screen and barograph.

T. FRANKLIN.

SUGGESTED SCHEME OF WORK

FIRST YEAR

THE MAP—Scales, Distance, Area—Ordnance Survey Signs—Simple Contours. (Section IV., Chapters xviii., xix. and xx.).

ROCKS—Classification—Denudation—The Work of Rivers. (Section II., Chapters x., xi., xii., xiii.)

CLIMATE—Climatic Charts and Maps—Their Meaning—Atmospheric Moisture—Causes of Climate. (Section V., Chapters xxiii., xxiv., xxv.)

THE EARTH AS A PLANET—Shape, Size—Rotation of Earth—Simple Ideas of Latitude and Longitude. (Section I., Chapters ii. to vi.)

The above studied in conjunction with a detailed knowledge of Home Region and a more general knowledge of British Isles.

SECOND YEAR

REVOLUTION OF EARTH—Seasons—Latitude and Longitude, how determined. (Section I., Chapters vii. and viii.)

TRADE WINDS—Their Cause—Direction—Migrations of Thermal Equator—Climatic Belts. (Section V., Chapter xxvi.)

EARTH'S STRUCTURE—The Work of Ice—Formation of Lakes and Waterfalls—Forces working inside the Earth—Volcanoes and Earthquakes. (Section II., Chapters xii., xiv. and xv.)

CONTOURS AND SECTIONS—Simple Surveying—Maps and How they are Made. (Section IV., Chapters xxi. and xxii.)

The above studied in conjunction with General Geography of the Three Southern Continents.

THIRD YEAR

SUN AND MOON—Moon's Phases—Eclipses. (Section I., Chapter ix.)

THE OCEANS—Depths—Temperatures—Waves—Tides—Ocean Currents. (Section III., Chapter xvi. and xvii; Section V., Chapter xxviii.)

PERIODIC AND VARIABLE WINDS—Monsoons—Cyclones. (Section V., Chapter xxvii.)

THE CLIMATIC REGIONS OF THE WORLD, and their Vegetation. (Section VI., Chapters xxix. to xxxii.)

More Difficult Exercises on CONTOURS AND SECTIONS. (Section IV., Chapter xxi.)

The above studied in conjunction with the Geography of Asia and North America on a regional basis.

FOURTH YEAR

NATURAL CAUSES INFLUENCING MAN'S CHARACTER AND OCCUPATIONS—Sites of Towns—Seaports—Transport—Peoples and Nations. (Section VII., Chapters xxxiv. to xxxvi.)

REVISION OF WORLD GEOGRAPHY on Basis of Climatic Regions. Revision of 1st, 2nd and 3rd Year's Work, with more Difficult Exercises.

The above in conjunction with a detail regional study of Europe and a more detailed study of the British Isles.

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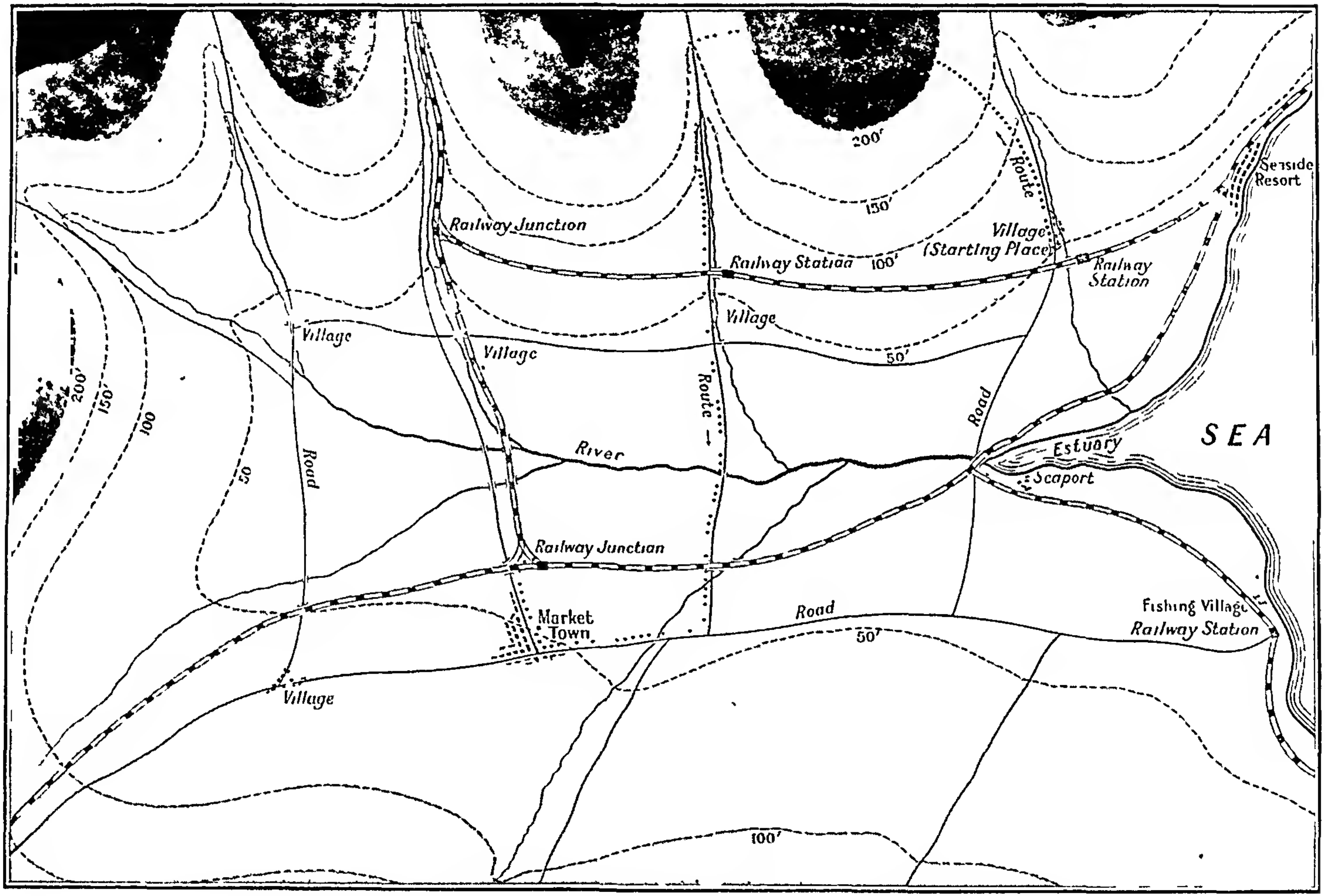


Map 1.—Contour Map of Hills and Valley.

EARTH LORE

CHAPTER I

INTRODUCTION

COME with me for an imaginary country walk. After an early breakfast we shall start, while the sun is still low in the east, and the grass is wet with dew. Climbing to the top of a high hill we get a glorious view. Away to the north and west are other hills as high as the one on which we are standing, if not higher. To the south is a plain, across which, through rich cornfields and meadows, a slow stream flows eastward and will at last reach the sea.

Between the hill on which we now stand and the next is a steep-sided valley, from whose slopes drain numerous little streams. These flow to the bottom of the valley and form a rivulet. Notice that jet of clear water which comes bubbling out of the opposite bank. It is a spring, and the water from it helps to swell the stream in the bottom of the valley. Let us follow this stream for a short distance, and see what we can learn from it. Notice that the water is moving very quickly. This is because the valley is steep. The bed of the rivulet is covered with large rounded stones, while the smaller stones and sand are being carried along by the current. We should not like to drink this water, it is so muddy. As we walk along we come to a sudden drop in the bed of the stream, and here the water dashes over the rocks, forming a small waterfall. Following the course of the rivulet we notice that, as its channel becomes less steep, so it flows more slowly. The slopes on either side of the stream decrease in height, and very soon the rivulet leaves its valley, and

finds its way across the plain to join the main river, which is flowing eastward.

By this time we notice that the sun is much warmer, and that, instead of being low down in the east, it is nearly overhead. Near the meeting-point of these streams there is a bridge over the river. This we cross, and come to a small village. Running side by side with the river, but at some distance away, we see both a railway and a road. We shall cross the railway and follow this road. As we journey we notice that other streams draining steep-sided southern valleys flow down to join the larger river, thus increasing its volume of water and making it wider. Roadways, and in one instance a railway, lead up these valleys across the hills, and where these streams leave their separate valleys groups of houses are built, forming villages.

As we have walked a long way we shall rest at this farmhouse, and ask the farmer's wife for some milk. While we drink this, and eat the lunch we have brought with us, the farmer tells us that the land on both sides of the river is very fertile, and that he can grow wheat, barley, and oats, while near the stream are rich meadows which provide grass for his cattle. He tells us that sometimes during the winter and spring the small streams bring down so much water that the river overflows and covers his land with rich mud, which is good for his crops. We can now see why the road and railway are built at some distance from the river. While we have been eating our lunch a black cloud has darkened the sky above our heads, and soon it begins to rain. We wait till the rain has stopped, and some of us grumble about the weather.

Soon the rain ceases and the sun comes out again, but as it is now afternoon we must find the nearest way home. We therefore walk to the railway station close by. This we find where an important road across the hills meets the road which follows the river. Having to wait twenty minutes for a train, we walk through the village

which has grown up at the meeting-point of these roads. There we see a number of farmers who have come to the village market to buy and sell cattle and other farm produce. We hurry back and just catch our train. Looking out of the window we learn still more of the country around us. We arrive home very tired and hungry.

After tea we draw a map of our day's journey. A copy of this will be seen on Map 1.

In this book you will learn about the things we saw on our imaginary journey and the reasons for them. In whatever part of the country you live you can take similar walks. You may not see the same things, but you will see others quite as interesting. Keep your eyes open and learn all about the country around you. Every stone, every little plant, every raindrop has each its tale to tell of the work it does in this world. When you have learned all about the country around you, you will be able to understand much about the geography of other parts of the world.

SECTION I.—THE EARTH AS A PLANET

CHAPTER II

THE STORY OF THE HEAVENS

PEOPLE in olden days believed that the earth was flat and floated on the surface of a boundless ocean, whilst the sky was a blue canopy resting on the tops of the highest mountains. The Sun, which regularly rose in the east, travelled across the sky, and set in the west, became to them a god who, from nightly struggles with the demons of darkness, emerged triumphant at the hour of dawn. Such a god, upon whom they depended for

their light and warmth, and who, when he was pleased, sent his brilliant rays to ripen their crops, was an object of worship to whom they erected magnificent temples. We can well imagine the awe and dread they felt when the sun's light was completely or partially obscured in what we now know as an eclipse.

The Moon, too, was equally an object of wonder to

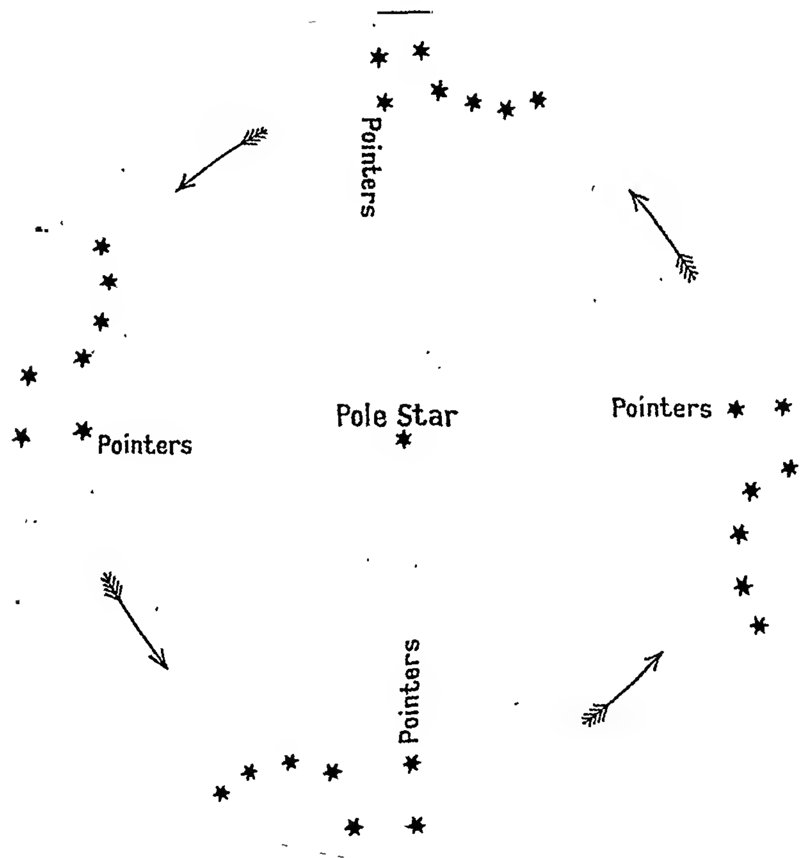


Fig. 1.—Circumpolar Revolution of Ursa Major (The Great Bear).

those early peoples. They noticed that at certain times it was not visible, and that later, starting as a crescent, it gradually increased in size to full moon and then waned again. This period of waxing and waning gave them the period which we call a month.

They also noticed that the moon and stars travelled across the sky in a similar manner to the sun. Ignorant

of what the stars really were, they formed them into groups which are called Constellations. These they named after fancied resemblances to certain animals or objects. Some of these groups rose directly in the east and set due west ; others, making a smaller arc across the sky, rose in the south-east and set in the south-west ; and still others, having a much longer path, rose in the north-east and set in the north-west. Some of the Constellations made a complete revolution round the North Pole Star without setting at all. Fig. 1 shows such a constellation, known as the Great Bear, or the Plough, and the two stars of this group which are in a line with the *North Pole Star* are known as the *Pointers*.

These stars were called *Fixed Stars*, because they kept the same distance away from one another ; but there were others that did not keep such a fixed relative position, and these were called *Planets* or *Wanderers*. The same stars were not always visible. Groups altered their direction in the sky and disappeared, while other groups came into view. The period of time which elapsed between the stars occupying the same relative positions again gave the term *year*. If you travel south of the Equator you will find that not only do other groups of stars come into view, but that certain of these Constellations circle round the Southern Cross, which, in the Southern Hemisphere, occupies a similar position to the Pole Star in the Northern Hemisphere.

You will find it a most interesting study to discover these groups of stars in the sky and their different positions at certain times of the year. You should first obtain a star map or planisphere, which can be purchased quite cheaply. From it you will be able to find out what stars are visible at any time of the year. It will be well if at first you get some one, who knows something about the position of the stars, to help you. First of all find the Great Bear, and by its Pointers locate the position of the Pole Star. From this point gradually work outward towards the horizon. Fig. 2 shows the chief stars visible between 8 and 10 p.m. on a clear evening in spring. Stretching right across the

sky you will see the *Milky Way*. This to the Chinese was the Celestial River, while to the Norsemen and the North American Indians it was the path by which the souls of the departed went to heaven. The Peruvians called it the Dust of Heaven, little dreaming that each grain of dust represents a star probably greater in magnitude than the sun.

Between the Great Bear and the Pole Star you will

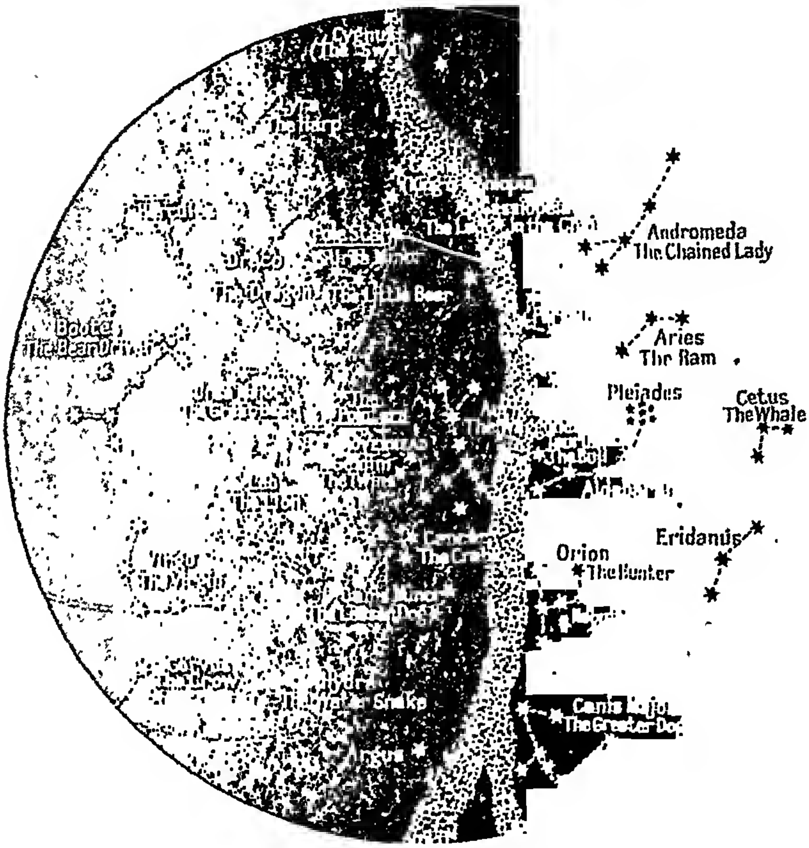


Fig. 2.—Stars Visible in Spring-time.

find a Constellation known as Ursa Minor, or the Little Bear. On the opposite side of the Pole Star to the Great Bear are five stars in the form of " W " in the Milky Way called Cassiopeia, or the Lady in the Chair. The line, which bisects the angle made by the first three of these stars, points directly to the Pole Star. On the other side of the Milky Way and nearer the horizon you will find Andromeda, the Chained Lady, with Aries, the Ram, farther south. Almost overhead is Auriga, the Waggoner.

As you get more accustomed to the stars you will be able to find Boötes, the Bear Driver ; Draco, the Dragon ; Lyra, the Harp ; and Cygnus, the Swan ; all near the horizon on your left.

If you turn to the south you will find two most interesting groups on your left : Orion, the Hunter ; and Taurus, the Bull. If you look at Orion through an ordinary telescope you will notice some clouds of wisp. These are vast clouds of gaseous matter called *Nebulæ*, from which new stars are being formed. Patches of gaseous matter such as this are formed in other Constellations, particularly in Andromeda and the Pleiades, the latter being a group of seven stars clustered close together near the Taurus Group.

Almost due south you will see the Twins, Castor and Pollux ; with Canis Minor, the Lesser Dog ; and Cancer, the Crab, farther away. To the right of Cancer are Leo, the Lion ; and Virgo, the Virgin.

If you choose another evening in the summer you will find these stars in a different position. The Milky Way is now low down on the other side of the horizon ; Auriga, the Waggoner, is no longer overhead but low on the horizon in the north ; Andromeda is now due north, with Cassiopeia to the left. Many of the Constellations you saw are not now in view, and others not visible in the spring have taken their place.

In the succeeding chapters we are going to learn that this earth of ours is a Planet, like other Planets is globular in shape, and has movements of rotation on an axis and revolution round the Sun. We shall also learn that the apparent movements of the sun, moon, and stars are not real, but are due to these movements of the earth, that the moon is a smaller body revolving round the earth, and that the other planets have similar moons revolving around them.

Greek students in Constantinople were the first to learn that the earth was round. Copernicus, in 1543, showed that the daily movements of the sun, moon, and stars were only apparent, and he proved that the real centre of the Universe was not the Earth, but the Sun, around which all planets revolve. Galileo, by the first use of a telescope, showed that Jupiter had four moons

revolving round it. Kepler found that the planets moved in elliptical orbits or paths round the sun.

Sir Isaac Newton discovered Gravity, a force we are going to learn about in a later chapter. He also invented a reflecting telescope which brought many other stars into view. Herschel, with his giant telescope, discovered many more stars and nebulæ.

Modern Astronomy and our knowledge of the stars have been greatly extended by improvements in the telescope and by the use of the camera and the spectroscope. By fixing cameras to telescopes it is possible to obtain, on a photographic plate, impressions never seen by the naked eye of the observer.

The Spectroscope is an instrument used for breaking up light into different coloured rays which we call the Spectrum. You have seen a rainbow which shows ordinary light broken up into red, orange, green, violet, and other coloured rays. You can get the same result by making light pass through a triangular prism of glass. Minerals, in a molten condition or gaseous form, produce certain definite lines into such a spectrum. If, therefore, light from the sun or from the stars produces these lines in the spectrum, we can say that certain minerals exist in that body. In this way much has been learned about the composition of the celestial bodies.

EXERCISES

1. State the apparent motions of the Sun, Moon, and Stars. How do the Planets differ from the other stars ?
2. Show how you would find the position of the Pole Star.
3. How has the Spectroscope enabled us to learn of different minerals found in the stars ?

CHAPTER III

THE PLANETS

OBSERVATION by astronomers has now proved that the sun is the centre of a system around which revolve a number of globular bodies that we call Planets. The so-called Fixed Stars are at such immense distances

away that we cannot see their real movements. These fixed stars are similar to our sun and probably have planets revolving round them.

The distances of the nearest stars can be measured by observation, and the one nearest to us is nineteen billions of miles away. This means that rays of light which it emitted four years ago are now reaching us. The great majority of the stars are very much farther away, and we are now seeing rays of light sent out from them hundreds of years ago.

The number of stars visible to the naked eye is about 3000, but the telescope has made it possible to see over 20,000,000. In addition there are those cloud-like masses known as *Nebulæ*, which are thought by astronomers to be other planetary systems in the making.

The Planets, being much nearer to us than the stars, can be observed much more closely, and our knowledge of them is therefore much greater. The Sun is 93,000,000 miles away from the earth, and between us and the sun are the planets *Mercury* and *Venus*, whose orbits or paths round the sun are much shorter than that of the Earth. *Mars*, *Jupiter*, *Saturn*, *Uranus*, and *Neptune* are farther distant from the sun and as a result have longer paths or orbits. Between Mars and Jupiter there are a number of smaller bodies which we call *Minor Planets* or *Asteroids*.

If we represent the distance of the sun from the earth (93,000,000 miles) by one inch, then ·4 inches would represent the distance of Mercury from the sun, ·7 inches the distance of Venus, and 1·6 inches the distance of Mars; 2·8 inches would represent the distance of the Asteroids, 5·2 inches the distance of Jupiter, 10 inches the distance of Saturn, and 19 inches the distance of Neptune. If you take a large sheet of paper you can draw circles at these distances with the sun as the centre. They will represent the orbits of each of the planets. The actual orbits are elliptical in shape, but are almost circular.

The Earth takes 365 days to revolve round the sun, but, because the orbits of the Planets vary in length, so also do their periods of revolution. Mercury completes its orbit in 88 days, while Jupiter's year is 60,127 days, or more than one hundred and sixty-four times as long as ours.

These planets are not all of the same size. Venus is only a little smaller than the Earth, but Mars and Mercury are much smaller. Jupiter, the largest planet, is nearly eleven times, and Uranus and Neptune are more than four times the size of the Earth.

Our knowledge of the Planets will help us to understand how the Earth was first formed. Jupiter is a very much larger body than the Earth, and is now surrounded by a great envelope of dense clouds. This leads us to suppose that it is not yet a solid body. Mars, on the other hand, is much older than the Earth, and, as it is rapidly losing both its air and its water, any inhabitants it may have must be in a dangerous plight. From such observations as this it is thought that the Planets were originally thrown off in gaseous form or as nebulæ from the sun. As they rotated on their axes and revolved round the sun, they gradually cooled and contracted. Bodies, cooling under these conditions, would assume the shape of the Planets.

The Planets give us many of the names of the days of the week. Sunday and Monday are Sun's and Moon's day respectively. The French word for Tuesday is Mardi, or Mar's day. Wednesday in French is Mercredi, or Mercury's day. Jupiter's day is Thursday, and Friday belongs to Venus. Saturn's day is Saturday.

In the same manner that the moon revolves round the earth in a Lunar Month, so the other planets have moons revolving round them. Mars has two such moons, Uranus four, Jupiter nine, and Saturn ten. Neptune has only one moon at present discovered. In addition to these moons, Saturn has three rings of light revolving in streams around the planet.

EXERCISES

1. Show how the planets resemble the Earth. How do they differ from the fixed stars ?

2. Explain why the time taken by the planets to revolve round the sun varies.

3. How was the Earth formed ? Show how the condition of the other planets helps us to arrive at this conclusion.

CHAPTER IV

THE SHAPE OF THE EARTH

THE Earth is not quite a perfect sphere, because its polar axis is slightly shorter than its equatorial axis. The diameter of the Earth, however, is roughly 8000 miles, and as the polar axis is only twenty-seven miles shorter than the equatorial axis, it is too small a difference to show on the school globe. The circumference of the Earth is approximately 24,800 miles.

We have learned in the previous chapter that the Earth was probably once a molten mass. Such a body, cooling whilst rotating, would assume the oblate spheroidal shape of the Earth, *i.e.* it would have the same relation to a true sphere that an ellipse bears to a circle.

Proofs of Globular Shape of Earth

Shape of Shadow in Eclipse of Moon.—The shadow which the earth casts upon the moon in an eclipse of the moon is always circular. The only body which always throws a circular shadow is a globe or ball. The earth always throws a circular shadow, which proves its globular shape.

Circumnavigation of the Globe.—If you started from any point and kept travelling in the same direction you would come back to the same place you started from. If the earth were flat you would somewhere come to an edge.

Bedford Level Experiment.—Three upright posts of the same length are set up at regular intervals in a straight line on a level plane, or three masts of equal length can be set up similarly on a sheet of calm water. If the earth were flat and an observer looked through a telescope from the top of the first post at the top of the third, he would find the top of the second post in the same line. Actually he finds the top of the second post above the line joining the tops of the first and the third, and this can only be accounted for by the globular shape of the earth.

The Shape of the Horizon.—An observer from a ship's deck, a masthead, or a tower sees the horizon at sea, or on a level plane, as a circle, and the higher he ascends from the ground the greater is this circular horizon.

Proofs of Earth's Oblateness.—A body weighed by a *spring balance* weighs least at the Equator, and its weight slightly increases as the Poles are approached, where it weighs the most.

Gravity.—A book falls to the floor because the force of gravity is pulling it towards the centre of the earth. A load you are carrying is heavy because the force of gravity is trying to pull it towards the centre of the earth. Weight is therefore a measurement of the force of gravity. This force decreases with distance from the centre of the earth, hence it is least at the Equator and greatest at

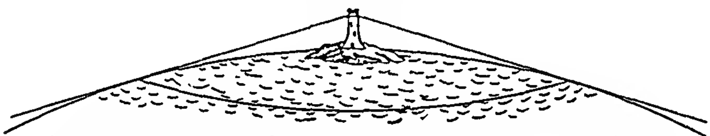


FIG. 3.—SHAPE OF HORIZON.

the Poles because the polar axis is shorter than the equatorial axis. It is necessary to use a spring balance to ascertain this, because in an ordinary pair of scales the force of gravity on the weights used would be the same as on the body weighed.

It is this force of gravity exerted by the sun on the earth and other planets that is partly responsible for their elliptical paths or orbits, and a similar force exerted by the earth is responsible for the elliptical orbit of the moon.

EXERCISES

1. Suppose that the axis of your school globe is sixteen inches in length, prove why it is impossible to show on it that the polar axis is shorter than the equatorial axis, *i.e.* that the earth is an oblate spheroid.

2. Draw a diagram to show why weight (measured with a spring balance) increases with distance from the Equator.

3. Draw a diagram to show how the Bedford Level Experiment proves the globular shape of the earth.

CHAPTER V

THE ROTATION OF THE EARTH

IF you imagine a peg-top spinning with its axis slightly tilted, and the peg tracing out an ellipse as it moves over the surface upon which it spins, you will be able to understand the two movements of the earth—*Rotation* and *Revolution.* The earth spins or rotates on an inclined axis once in twenty-four hours, in the same manner that you can make your school globe rotate. At the same time the earth revolves round the sun, and this period of revolution we call a year.

Rotation of the Earth causes Day and Night.—As the earth rotates, so each part receives light while it is turned towards the sun, and is in darkness when it is turned away from it. Because of this rotation places east of us get their sunrise before, and places west get their sunrise after us.

Rotation of the Earth causes the Apparent Motions of the Sun, Moon, and Stars.—When you are travelling in a railway train the objects in the carriage do not appear to be moving, but the telegraph poles, trees, and other objects outside appear to be running away from you. You know they are not moving, but that it is the train in which you are seated that is moving. In the same way the sun appears to travel across the sky from east to west, because we are looking at it from a moving earth which is *rotating from west to east.*

Rotation also causes the *Oblate Spheroidal Shape* of the Earth, and causes the Tides to vary in height at different times of the day.

Proof of the Earth's Rotation

Foucault's Pendulum Experiment.—In this experiment a heavy ball hung by a long, thin wire is suspended from a roof in such a way that it is *free to move in any plane.* The pendulum is pulled aside by a thread, which when burnt releases it, so that it is free to move in any direction.

Such a *pendulum will continue to swing in one plane,* but a table placed below the pendulum is found to turn round in twenty-four hours, proving that the earth rotates from west to east.

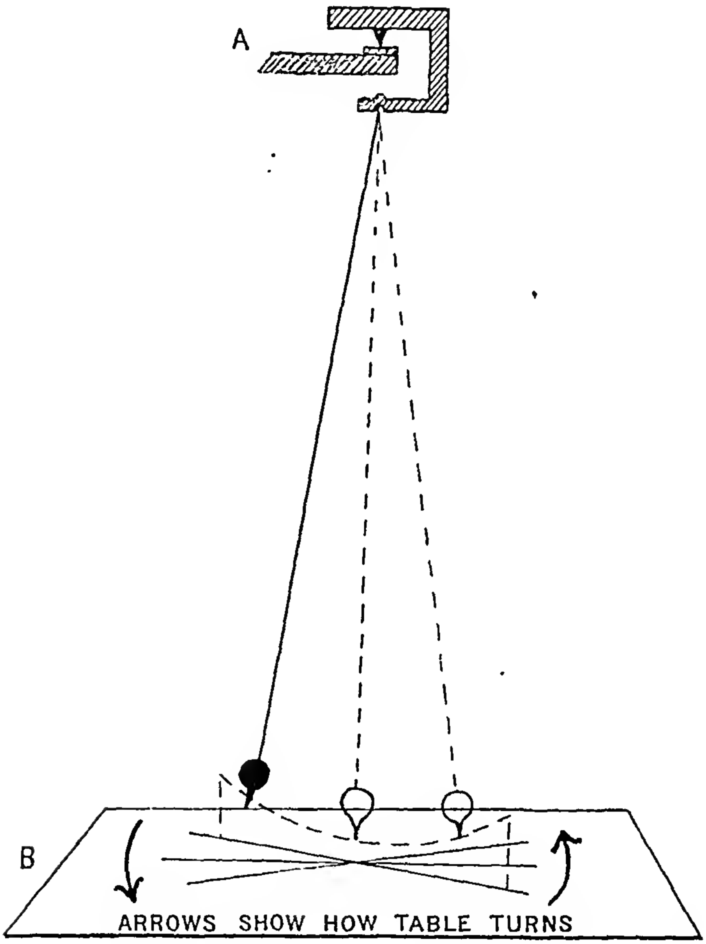


FIG. 4.—FOUCAULT'S PENDULUM.

EXERCISES

1. Explain why Australia has its night when we have our day, and why, when we are having our midday meal, the people in New York are having their breakfast.

2. What are the effects of the Rotation of the Earth ?

3. Prove that the Earth rotates on its axis once in twenty-four hours.

4. If the Equator measures 25,000 miles, and the 60° parallel of latitude measures 12,500, at what speed per hour would a point on each parallel travel because of the earth's rotation ?

CHAPTER VI

LATITUDE AND LONGITUDE (1)

BEFORE proceeding any further, it will be necessary to learn how to locate the position of any place on the globe. To do this it will be necessary to have two systems of measurement—one, a north and south measurement known as *Latitude*, the other an east and west measurement called *Longitude.*

If you were asked to place a dot in a certain position on a blank sheet of paper you would require two sets of measurements. If you were told the point was 3 inches from the bottom edge of the paper it might be anywhere on a line drawn 3 inches from that edge. Similarly, if you were told it was 5 inches from the left-hand side, you would know that it would be on a line 5 inches from that edge. If, however, you were given both measurements, you would know that the exact position would be where the two lines intersected. Note that these lines cut each other at right angles.

On a globe we have no top and bottom edges, but we have two points fixed with reference to the stars—the North Pole and the South Pole—and the line joining these is the earth's axis. Any North and South section of the earth through the Poles gives a circular plane whose diameter equals the diameter of the earth, and an East and West section through the earth, half-way between the Poles, also gives a circular plane—the plane of the Equator —whose diameter equals the diameter of the earth. We can have an infinite number of such North and South earth-diameter sections through the Poles, but only one such East and West section—the plane of the Equator. Every East and West section, parallel to the plane of the Equator, becomes smaller and smaller as we go towards the Poles.

The circumferences of such North and South and East and West planes cut each other at right angles, and are called Parallels of Latitude when East and West, and Meridians of Longitude when North and South. Such

earth-diameter circles on the globe are called Great Circles, and while each Meridian of Longitude is half a Great Circle, the Equator is the only East and West Great Circle, for it is the only earth-diameter circle whose plane is perpendicular to the Earth's polar axis.

Latitude is angular measurement north or south of the Equator. It is the *angle made by two lines meeting at the centre of the earth*—one on the plane of the Equator, and one through the place specified to the centre of the earth.

Fig. 5 shows such an angle. The latitude of A is 60°, because the line joining A to the centre of the earth makes an angle of 60° with the plane of the Equator. This figure also shows that if the line C A were hinged at C, so that the point A could swing in a circle parallel to the plane of the Equator, it would trace a circle of which B A is an arc. Every point on that circle would be 60° north of the Equator. Such a circle is called a Parallel of Latitude.

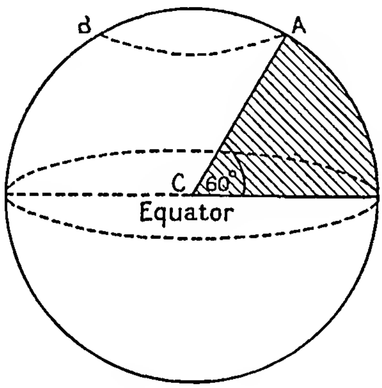


FIG. 5.—LATITUDE.

Parallels of Latitude are lines joining all places which have the same angular distance north or south of the Equator. Such parallels are all less in length than the Equator, and decrease in size with distance from it. Hence they are sometimes called *Small Circles.*

Longitude.—It was easy to fix the Equator, because it was the only East and West Great Circle, but as each Meridian of Longitude is a Great Circle, we must fix on ONE as a starting circle from which to measure angular distance east or west, or as we call it, Longitude. Look at your globe and trace the meridians from the North to the South Pole. Notice the one labelled 0°, which passes through Greenwich and is known as the Prime Meridian. All maps published in Britain take their east and west measurements from this line, but other countries use other fixed meridians. Longitude is the

angular measurement between two planes which meet in the polar axis : one plane passes through the fixed meridian of Greenwich, and the other passes through the place whose longitude we are considering.

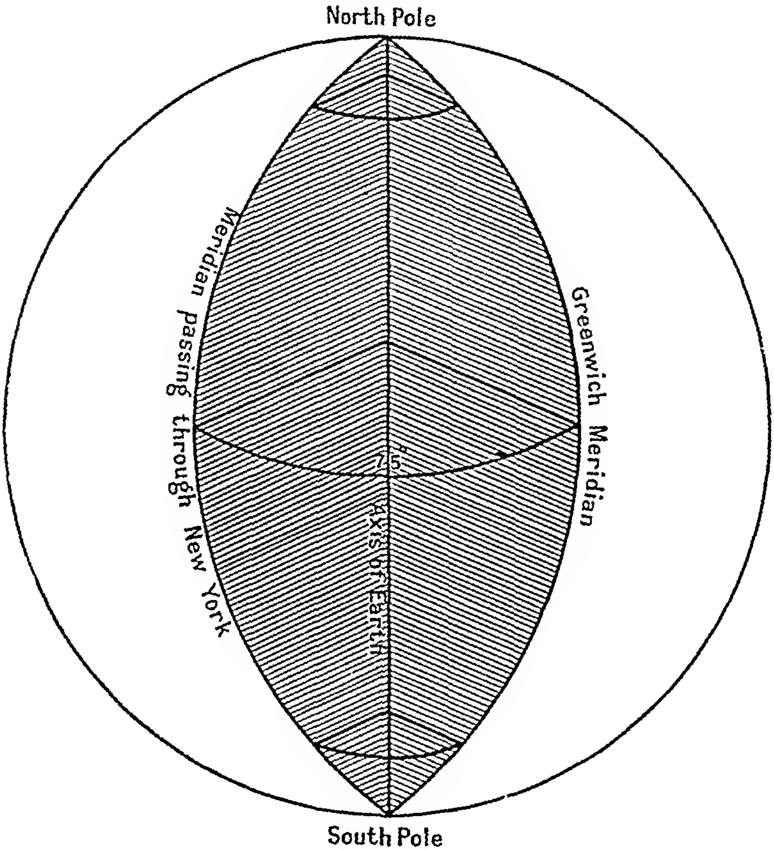


FIG. 6.—LONGITUDE.

If we are told that New York is 75° west of Greenwich, it means that a plane passing through New York will make an angle of 75° with one passing through Greenwich. Notice that the meridians which are the boundaries of these planes are the same length, being half Great Circles and having the axis of the earth as their diameter. A Great Circle is therefore the boundary line of a plane which cuts the earth in halves. The Equator is therefore a Great Circle, and two meridians, the one on the opposite of the world to the other, will together make a Great Circle.

If you take two or three of the sections from a peeled orange you will get a correct impression of Longitude. You will see the two planes meeting in the polar axis, in the interior which you can now see, because you have removed some of the sections. The boundary lines of these planes will be meridians, and so too will each of the lines which mark the position of the other sections.

Notice that the *length of a degree of Longitude varies.* It is greatest at the Equator where the two planes diverge the most, and much shorter towards the Poles where the planes converge to the earth's axis.

The length of a degree of Latitude, on the other hand, *is nearly the same everywhere.* You can see this if you draw a circle on a piece of paper. In this circle draw a line from the centre to represent the Equator, and from this draw an angle of 10° from the centre to the circumference. Draw another angle of 10° from the North Pole. You will find that the parts of the circumference bounded by these angles are the same. Similarly, if the angles were only of 1° each, the parts of the circumference bounded by them would be equal, and the same is true of angles from the centre to the circumference of a sphere. You have learned that the earth is nearly a sphere, so that the lengths of a degree of latitude are nearly the same everywhere.

Comparisons of Meridians of Longitude and Parallels of Latitude :

Latitude	*Longitude*
1. Lines of latitude are parallel to the Equator.	1. All meridians meet at both Poles.
2. All parallels of latitude are "small circles" and divide the earth unequally, *except the Equator, which is a "great circle."*	2. Each meridian is half a "great circle." (A great circle cuts the earth into two exact halves.)
3. Degrees of latitude measured along a meridian are approximately 69 miles.	3. Degrees of longitude measured along a parallel of latitude decrease from approximately 69 miles at the Equator *to half this* in latitude 60° N. or S. (*e.g.* that of Shetland Islands), and *to nothing at all* at the Poles.

Great Circle Sailing.—The shortest distance between two places on the earth's surface is along the arc of a Great Circle passing through them. As all meridians of longitude are half great circles, the shortest distance between any two points north and south of one another is on the meridian

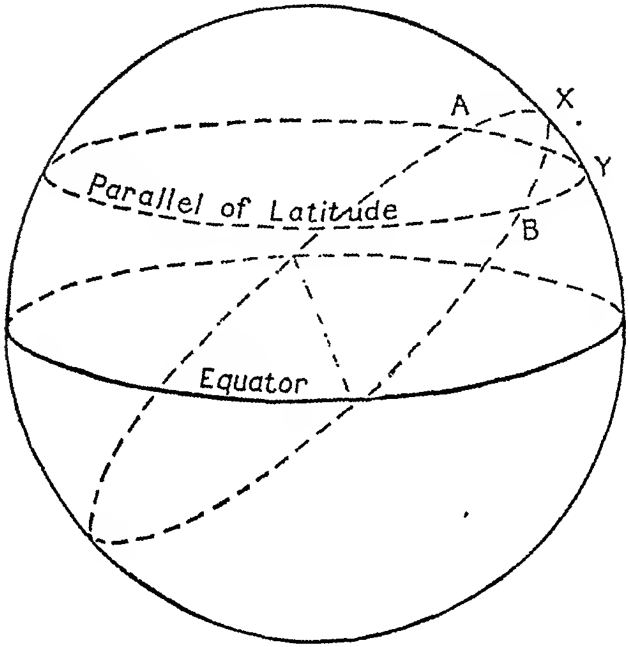


Fig. 7.—Great Circle Sailing.

passing through them. The shortest distance between two points east and west of one another (except on the Equator) is not on the parallel of latitude passing through them, because it is not a Great Circle. In Fig. 7 the shortest distance between A and B is A X B, part of the Great Circle passing through these points, and not A Y B, which is part of the parallel of latitude passing through them.

In a later chapter we will learn how to find both the Latitude and Longitude of any place, but we must first know something of the Revolution of the earth round the sun.

EXERCISES

1. Explain why the length of a degree of Latitude is nearly the same everywhere, while the length of a degree of Longitude varies.

2. Explain why lines of Latitude are parallel, and meridians of Longitude are not, and why lines of Longitude are all the same length, while those of Latitude vary.

3. The shortest distance between two points east and west of one another is not on the parallel of latitude passing through them. Explain why.

4. Find from your atlas the latitude and longitude of the following to the nearest degree: Melbourne (Australia), Montreal (Canada), Bombay (India), Aberdeen (Scotland), and Dublin (Ireland).

5. Find the names of places having the following latitudes and longitudes:

50° 6′	N. Lat.	and	5° 35′ W.	Long.
48° 50′	,,	,,	2° 20′ E.	,,
40° 25′	,,	,,	3° 21′ W.	,,
55° 0′	,,	,,	7° 20′ W.	,,
52° 45′	,,	,,	13° 24′ E.	,,
41° 0′	,,	,,	29° 0′ E.	,,

(A minute, shown ′, is one-sixtieth part of a degree.)

CHAPTER VII

THE REVOLUTION OF THE EARTH

FIGURE 8 shows that the earth moves round the sun in an almost circular path or orbit, with the sun not quite in the centre. You will notice that the Polar axis is inclined in a similar manner to that of the axis of your school globe; also that between March and September the North Pole leans towards the sun, while in the other half of the year the South Pole leans towards it.

This movement of the earth round the sun is the cause of the *Seasons*, and in this chapter we are going to learn why the periods of daylight vary in length, and why the sun sends us oblique rays in winter and nearly vertical rays in summer.

You should take daily observations of the length of the shadow cast by a stick or post placed upright in the playground or garden. See that it is far removed from buildings. You will notice that the lower the sun is in the sky, the longer is the shadow cast by the stick. Now at the same time each day, preferably in your dinner interval, take observations of the length of the shadow. You will notice that, as the days get gradually longer, and the sun rises higher in the sky each day, so does the length of the shadow get shorter. You can probably find the

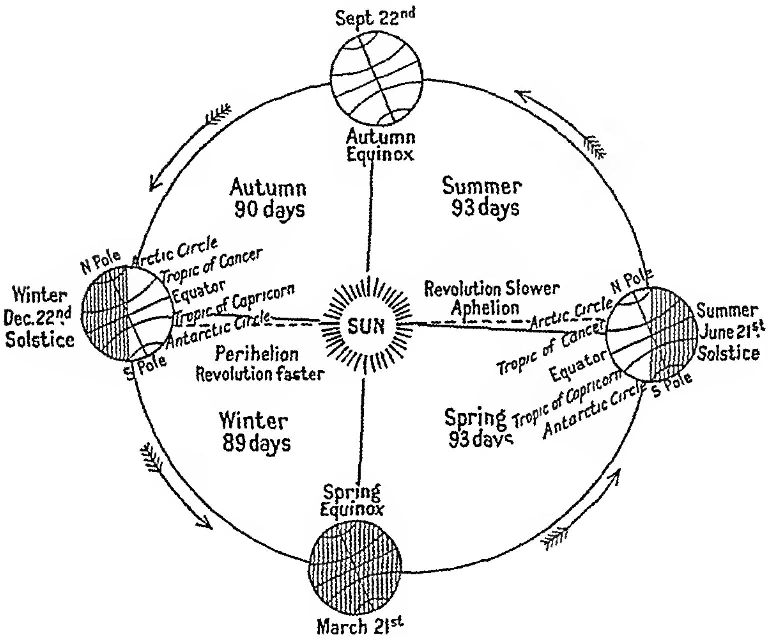


FIG. 8.—THE EARTH'S ORBIT—THE SEASONS.

actual time of sunrise and sunset from your local newspaper each day. You should compare the length of the shadow with the length of the day.

Your own observation will show you also that in winter the sun rises in the south-east, makes a small arc across the sky, and sets in the south-west. In spring, when the days are the same length as the nights, the sun rises in the east and sets in the west; and as the days lengthen in summer, so it rises in the north-east, travels nearly overhead, and sets in the north-west. After Midsummer's Day the days shorten again, and the path of the sun becomes shorter.

Midsummer Solstice

The word Solstice means "standing-point," and at the Midsummer Solstice we have reached the longest day in the year. Fig. 8 shows that the sun on that day is shining vertically over the *Tropic of Cancer*, $23\frac{1}{2}^{\circ}$ north of the Equator. This is *the northern limit of the sun's vertical rays.* The figure also shows you that, northward from the Equator, the length of each day is longer than south of it, because in the rotation of the globe its northern half is longer in the light than in the darkness. Notice that, as the Earth rotates on Midsummer Day, the *Arctic Circle* is in the light all the time, and has *twenty-four hours of daylight.*

After Midsummer's Day the sun shines vertically a little farther south each day, and the period of daylight gradually shortens in the Northern Hemisphere until the September Equinox (22nd September).

At the **Equinox** all places on the earth have twelve hours daylight, and the sun shines vertically over the Equator. Notice that neither Pole is now leaning towards the sun.

From September to March the South Pole leans towards the sun, and all places north of the Equator have a period of daylight shorter than twelve hours. Each day after the September Equinox the sun will shine a little farther south of the Equator until the December Solstice (22nd December).

The December Solstice, or Midwinter's Day, in the Northern Hemisphere

Fig. 8 shows that the sun is now shining vertically over the *Tropic of Capricorn, the southern limit of the sun's vertical rays*, that the days south of the Equator are longer than twelve hours, and that at the *Antarctic Circle* the period of daylight is *twenty-four hours.* In the

Northern Hemisphere the days are short, and at the Arctic Circle the sun does not rise at all.

From Midwinter's Day until the *Spring Equinox* in March the sun shines a little farther north each day, until on 21st March it shines vertically over the Equator, and all places again have equal periods of daylight.

Between March and June the days in the Northern Hemisphere gradually increase in length until the Solstice of Midsummer's Day.

The movement of the Earth in its orbit causes the sun to appear to move through the principal groups of the stars which are called the Signs of the Zodiac. On 21st June the sun appears to be in the Sign of Cancer, the Crab, and this gives the name to the Northern Tropic. Similarly in December the sun appears in the group of Capricorn, the Goat; hence the name of the Southern Tropic.

You can see the reason for this if you place a lamp in the middle of a room. Now if you look towards the light the objects on the wall behind it will be visible to you. If you now shift your position and again look towards the light, another set of objects on the wall will be in the same straight line with you and the light. In the same manner, owing to the Earth's revolution, you are looking from the Earth at the sun from different relative positions, and therefore different constellations appear in conjunction with it.

The plane of the Earth's orbit is called the ecliptic, and is so called because it is only when the moon is in this plane that eclipses of the sun and moon are possible.

Fig. 8 shows that the Sun is not in the centre of the elliptical orbit of the Earth, and that at the Winter Solstice the Sun is a little nearer the Earth than at the Summer Solstice. Notice, too, that when the Earth is in *Aphelion*, or farthest away from the Sun, it moves slower than in *Perihelion*, when the Sun is nearest the Earth.

Before proceeding further, it is necessary to understand why vertical rays from the sun are hotter than oblique rays. Fig. 9 shows two equal beams of rays coming from the sun, which, because the sun is so far away, are practically parallel. Notice that the vertical

beam has only to heat the space between *a* and *b*, but the beam which strikes the Earth obliquely has to heat the

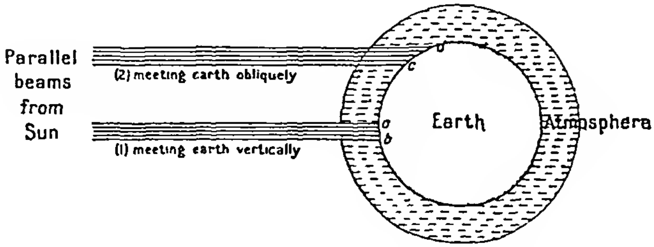


Fig. 9.—Vertical and Oblique Rays.

much larger space between *c* and *d*. The heat felt, therefore, between *a* and *b* is much greater than that between *c* and *d*.

The Zones of the Earth

Torrid Zone.—This is situated between the Tropics of Cancer and Capricorn. As some part of it receives vertical rays from the sun at some period of the year and nearly vertical rays during the remainder, the temperature is very high.

North and South Temperate Zones.—The North Temperate Zone lies between the Tropic of Cancer and the Arctic Circle, and the South Temperate Zone between the Tropic of Capricorn and the Antarctic Circle. In summer these receive more nearly direct rays from the sun than in winter. Fig. 8 shows also that every place in these zones, as the earth rotates, in summer spends more time in the light than in the darkness, so that the days are longer than the nights, while in winter exactly the opposite occurs. Therefore the Temperate Zones are much warmer in summer than in winter.

North and South Frigid Zones.—These lie between the Arctic and Antarctic Circles and the Poles. In summer the longest period of daylight in the North Frigid Zone varies from twenty-four hours on the Arctic Circle at the Summer Solstice to six months at the North Pole,

and similar conditions prevail during northern winter in the South Frigid Zone. Thus northern Winter is southern Summer. During their summers, however. they receive very oblique rays from the sun, and in winter much of their light is only reflected. Hence these Zones are cold.

Seasons in North Temperate Zone.—During (northern) *summer* the North Pole leans towards the sun, and, as the sun is shining vertically somewhere between the Equator and the Tropic of Cancer, the rays received are more direct than in winter, when the sun shines vertically somewhere south of the Equator. During this summer season the sun appears to rise in the north-east, travel across the sky, being nearly overhead at noon, and to set in the north-west, and thus the days are longer than twelve hours.

In *winter*, when the sun shines vertically south of the Equator, the rays received are much more oblique. During this season the sun rises in the south-east, makes a smaller arc nearer the horizon, and sets in the south-west; hence the days are shorter than twelve hours.

In *spring* and *autumn* the sun is shining vertically over the Equator, appearing to rise in the east and set in the west, and the temperature is not so high as in summer nor so low as in winter.

Varying Length of Daylight

At the Equator the sun always rises in the east and sets in the west, and every day is twelve hours in length. With distance from the Equator, the difference between the length of daylight in summer and in winter increases, so that, in such northern latitudes as in Norway, there is no real darkness at all in June and July, as twilight bridges the short period between sunset and sunrise. Similarly, in winter, the days are correspondingly short. We have already noticed that on the Arctic Circle on 21st June the sun does not set at all, and appears to make a complete revolution above the horizon. At the North Pole the sun only rises and sets once during the year. Between March and September the Pole is turned towards the sun and has daylight for six months, while in the remaining half of the year, when the South Pole leans towards the sun, the North Pole receives no direct sun rays

Twilight.—You probably have noticed that it is light before the sun rises in the morning and again after it has set in the evening. This "twilight" is caused partly by refracted light from the sun and partly by reflected light from air particles and moisture. It is greatest when the rays strike the earth obliquely. Hence at the Equator, where the rays are practically vertical, there is little or no twilight, and "When the sun's rim dips, the stars shoot out; at one stride comes the dark." In higher latitudes, where the rays are more oblique, twilight is very much longer, and in Arctic Regions provides the greater part of the light during winter.

EXERCISES

1. Measure the length of shadow cast by a six-foot pole each day for a month. Draw a graph to show the varying length of the shadow. At the same time ascertain the length of daylight for each of these days, and draw another graph. What relations can you deduce between the two graphs?

2. London never has the sun directly overhead, but Singapore, 2° north of the Equator, has it twice overhead during the year. Explain why this happens.

3. Explain why Christmas Day in Australia occurs in the Australian summer.

4. Cut out a circular piece of cardboard 4 inches in diameter. Draw another circle inside it with a radius of $3\frac{1}{2}$ inches. Divide the whole into twenty-four equal parts, and mark in one semicircle the twelve hours. Push a knitting-needle through the centre and fix it at right angles to the card by two corks. Set this up by fixing the needle on the tilt towards the north at an angle equal to the latitude of your town. The direction of the north you can find by the position of the shadow at noon. Compare the time by this simple sun-dial with that on your school clock.

5. What is the cause of the Seasons? Explain why (*a*) it is hotter at the Equator than at the Poles, and (*b*) hotter in summer than in winter.

6. Define Solstice, Equinox, Arctic Circle. Where does the sun always rise in the east and set in the west, and where does the sun rise and set once only during the year?

CHAPTER VIII

LATITUDE AND LONGITUDE (2)

How to determine Latitude

THE *Altitude* of the Pole Star is equal to the observer's latitude. Altitude is angular measurement above the horizon, and this can be obtained by a sextant.

Proof.—In Fig. 10, B A is pointing to the *Zenith*—that is, directly above the observer's head. The line C D, at right angles to B A, tangential to the earth's surface, and passing through the point of observation at B, is the *Horizon.* E B D is the angular distance of the Pole Star above this Horizon, or its *Altitude.* B G H is the angular distance of B from the Equator—that is, its *Latitude.* We have to prove that the angles B G H and E B D are equal. If G F is continued indefinitely it will reach the Pole Star, so also will the line B E, and, as these two lines will not meet for millions of miles, they are practically parallel. Therefore the angle E B A is equal to the angle F G B. But angles E B A and E B D together make one right angle, as also do angles F G B and B G H. Therefore the remaining angles E B D (the Altitude of the Pole Star) and B G H (its Latitude) are equal.

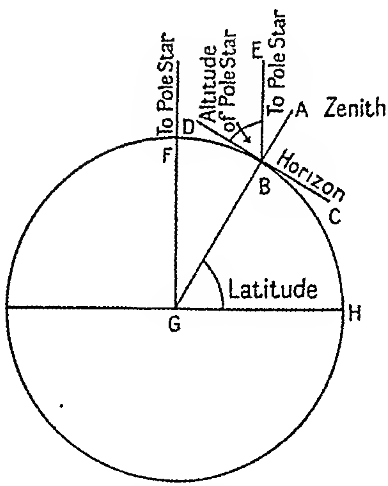


FIG. 10.—ALTITUDE OF POLE STAR.

The Noonday Distance of the Sun from the Zenith at the Equinoxes is equal to the Observer's Latitude.—The distance of the sun from the zenith, plus the sun's altitude, is equal to 90°, so that, if the altitude of the sun be found and

subtracted from 90°, we shall know the latitude. On dates other than the equinoxes, the latitude may be found by making a correction for the degree that the sun is shining vertically north or south of the Equator, which can be obtained from the Nautical Almanac.

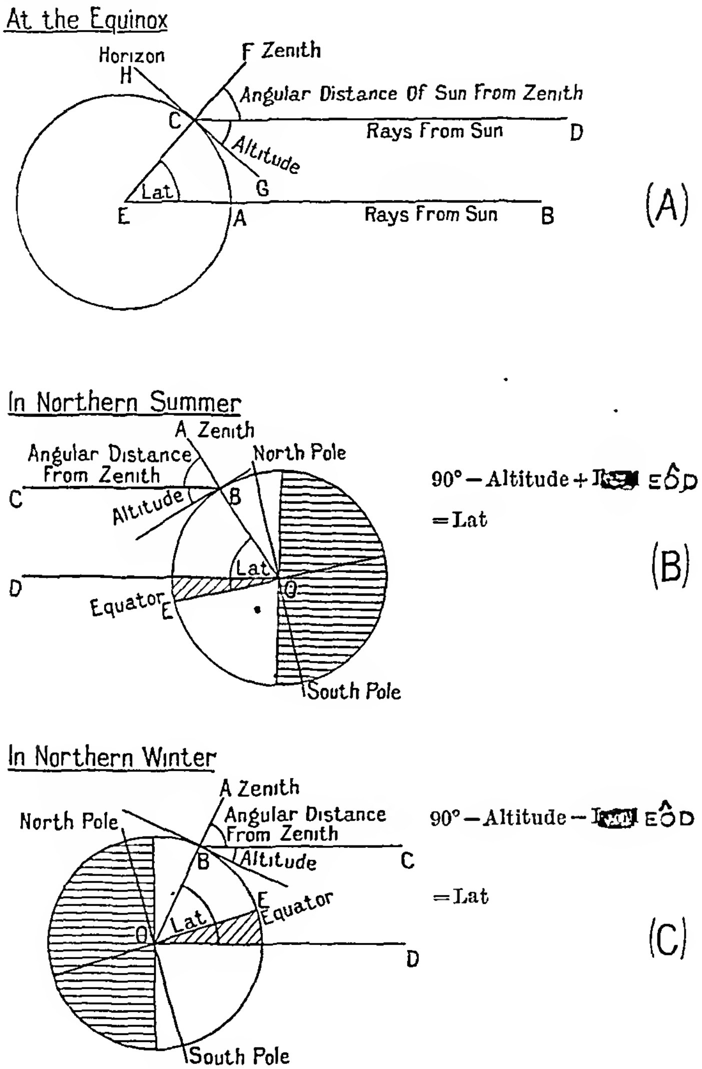


FIG. 11.—LATITUDE AND NOONDAY SUN.

Proof.—In Fig. 11 (*a*) B A is a ray from the sun at the equinox which is perpendicular to the earth, and if continued will pass through its centre E. D C is another ray practically parallel with B A, because the sun is such a vast distance from the earth. F C, the "normal" through C,

will, if continued, pass through the centre of the earth at E. Because D C is parallel to B E, the external angle F C D (angular distance from zenith) is equal to the internal and opposite angle C E A (the latitude).

Fig. 11 (*b*) shows the sun shining vertically north of the Equator in northern summer. Hence, to obtain the correct Latitude, it will be necessary to add to the Zenith Distance the angle that the sun is shining vertically above the Equator. Knowing that the sun's vertical rays shift through $23\frac{1}{2}°$ in a quarter of the year, we can by simple proportion find the angular addition to be added for any day. Thus on 7th May it will be necessary to add approximately $11\frac{1}{2}°$.

Fig. 11 (*c*) shows the opposite conditions prevailing in northern winter. In this case it will be necessary to subtract from the Zenith Distance the angular distance that the sun is shining south of the Equator. This on 7th November will be $11\frac{1}{2}°$.

Longitude and Time

The earth rotates through 360° in twenty-four hours —that is, through 15° in one hour and 1° in four minutes. Hence West to East rotation means that places to the east of us have their sunrise, noon, and sunset before us, while places to the west have them later. British time is the mean solar time at Greenwich, and, by a comparison between this time and the solar time at any other place, it is possible to determine its longitude.

New York is approximately 75° W. of Greenwich. Therefore its time is five hours behind Greenwich time, because it takes the earth five hours to rotate through that 75°. Hence a comparison of the solar time at the two places shows a difference of five hours.

If we travel eastward through 180°, solar time will be twelve-hours in advance of Greenwich time. Similarly, if we travel west through 180°, solar time will be twelve hours behind Greenwich time. Thus, when it is noon at Greenwich on 25th December, it is midnight between 25th and 26th December on 180° E., and midnight between 24th and 25th December on 180° W. A glance at the globe will show you that 180° E. and 180° W. are one and the same meridian. To avoid confusion, a vessel

crossing the 180° meridian, or the *International Date Line*, from the east adds a day to its reckoning, and the next day after Sunday is Sunday again, while one travelling from west to east omits a day from the calendar, and the next day after Sunday is Tuesday.

Fig. 8 in the preceding chapter shows that the earth does not travel always at the same rate; hence for convenience we take the average time at Greenwich. Sometimes we should find that the time, as registered by a sundial at Greenwich, would be slightly in advance of Greenwich Mean Time, and sometimes a little slow in comparison with it.

EXERCISES

1. Take two sticks. Place one upright in the ground and the other pointing to the Pole Star. Measure the angle between them and subtract it from 90°; the answer will be the latitude. Try to prove this.
2. The noonday altitude of the sun on 10th February was 15°. Find the latitude of the place.
3. A cricket match finished in Melbourne at 6 p.m. The result was known at 10 a.m. the same day in Britain. Explain how this was possible.
4. Explain why a day is apparently lost or gained in travelling round the world.
5. Define Altitude, International Date Line, and Zenith. Prove that the Altitude of the Pole Star is equal to the Latitude.
6. Whom would be most influenced by the Daylight Saving Act, a person living at Maidstone, Bristol, or Aberdeen?

CHAPTER IX

THE SUN AND THE MOON

The Moon

YOU must have noticed that the Moon appears in different shapes or *Phases* at certain periods of the month. At one time it will appear as a baby crescent lying on its back. Each day it will grow in size until at last it forms a complete circular disc, which we call *Full*

Moon. Then it will gradually decrease in size until it appears as a crescent lying on its face. The next night it will not appear at all, but later it will rise again as a crescent and pass through the same stages.

If you observe the Moon more closely, you will notice that it rises about fifty minutes later each day, so that sometimes it may rise just after sunset, and later in the month only just before sunrise. In this chapter we are to learn about the Moon, and account for both its phases and its movements.

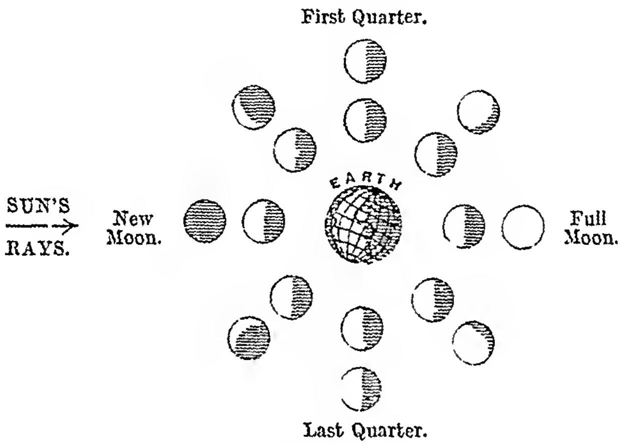


FIG. 12.—PHASES OF THE MOON.

The Moon appears to be nearly as large as the Sun because it is quite near to the Earth ; but actually it is only $\frac{1}{49}$th of the size of the Earth. The Moon revolves round the Earth in an almost circular orbit, with the Earth not quite in its centre. This period of Revolution takes $29\frac{1}{2}$ days, and is exactly the same time that the Moon takes to rotate on its axis. As a result of this, the same side of the Moon is always turned towards the Earth. The Moon has no light of its own, and only reflects the light of the Sun. This fact, coupled with its Revolution round the Earth, explains the cause of the Phases of the Moon.

If you place a lamp to represent the Sun, an orange to represent the Earth, and a very much smaller ball to

represent the Moon, on a table in the positions shown in Fig. 12, you will be able to understand the Phases of the Moon. When the Moon is between the Earth and the Sun, the half of it, which is illuminated by borrowed light from the Sun, is completely turned away from the Earth, and at New Moon we see no light from it at all. Keeping the lamp and the orange in the same position, but moving the small ball to the right in its circular orbit, you will find that a very small portion of that half of the ball which is illuminated by the lamp is visible from the orange, and that this forms a crescent. By continuing to move the ball round the orange you will be able to understand all the different phases of the Moon shown in Fig. 12.

Fig. 13 shows why the Moon rises later each day. While the Earth has made one complete rotation in a day the Moon has moved on in its orbit, and consequently the Earth has to make more than one complete rotation before it is again in the same position with reference to the Moon.

You will notice on a fine night that the outlines of the Moon are very clearly marked. This is because it is a dead body, and is not surrounded by an outer envelope of air. As there is no air, there cannot be any plant or animal life on the Moon similar to that on the Earth.

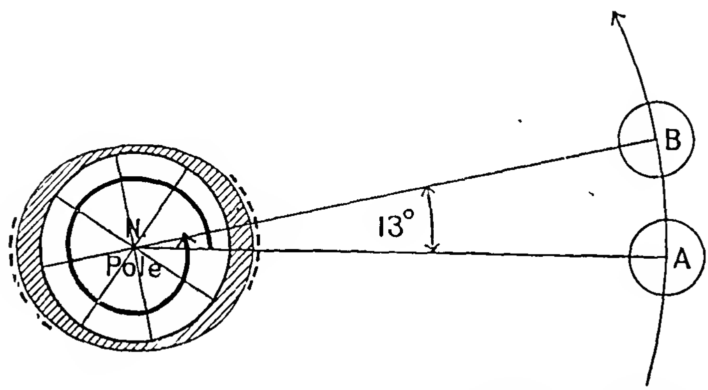


FIG. 13.—THE EARTH'S ROTATION AND THE MOON'S REVOLUTION.

Eclipses of the Sun and Moon

An Eclipse of the Sun occurs when the shadow of the Moon is thrown on the Sun, and, from what you have learned so far, you might suppose that eclipses ought to occur at New Moon each month. The plane of the Moon's orbit, however, does not coincide with that of the Sun, but is inclined to it. Hence at New Moon the sun,

moon, and earth are not always in the same straight line, and the moon passes above or below the line joining the sun to the earth. They are in a straight line only when the two planes intersect, and then an eclipse occurs.

Fig. 14 (*a*) shows such an eclipse. The part of the Earth between *a* and *b* has a *Total Eclipse* of the Sun, and is in total darkness. Outside this area between *c* and *d* there is a *Partial Shade*, called the *Penumbra*. It is impossible to show correctly on a diagram the relative sizes of the Sun, Moon, and Earth, and their distances away from one another. Actually the area of the total eclipse and also that of the Penumbra are much smaller than those shown in the figure, because the Moon is in reality relatively much smaller than it is shown in the diagram.

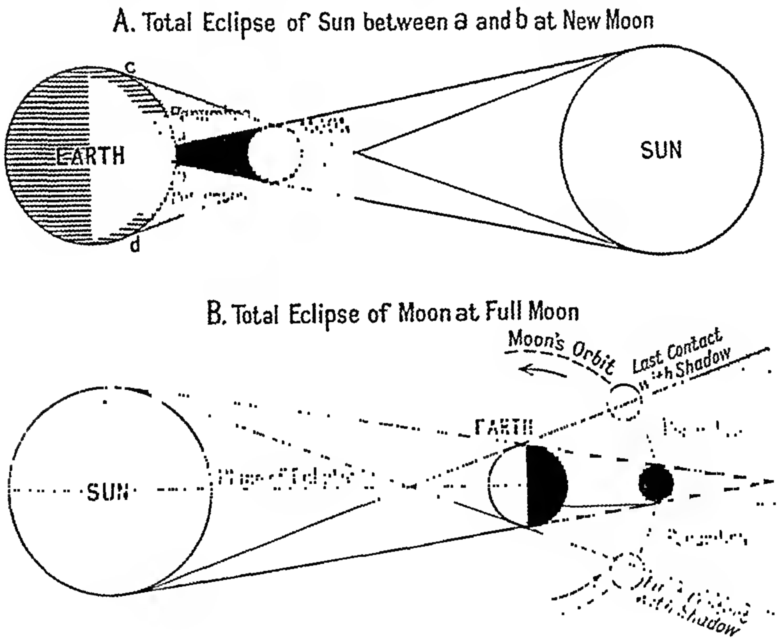


FIG. 14.—ECLIPSES OF THE SUN AND MOON.

A Total Eclipse of the Moon (Fig. 14*b*) occurs at Full Moon when the planes of the orbits of the sun and moon intersect. It is caused by the shadow of the earth obscuring the light from the moon. If the sun, earth, and moon are nearly in a straight line, a partial eclipse of the moon occurs.

A total or partial eclipse of the moon can be seen over more than half the earth, but a total eclipse of the sun is only visible over a very small area.

The Sun

The Sun, which is 93,000,000 miles from the Earth, is an immense body one and a half million times the size of our planet. Its heat is so intense that no part of it is solid, and minerals which are found on the earth in a solid form exist there in a gaseous state. Such a body shines by its own light, and its rays are dangerous to look at with the naked eye. Sometimes it is possible to see, through a darkened glass, black spots which pass across the sun's disc. Observations through a telescope show that such spots take twenty-five days to pass across the sun's disc and to reach the same positions again. This leads us to suppose that the sun rotates on its axis in that time. Near the spots are immense masses of bright vapours, many thousands of miles in extent. A less dense atmosphere of luminous vapours reaching for many hundreds of thousands of miles surrounds the visible sun. These vapours are of beautiful colours, and are only visible during an eclipse of the sun, when the sun's light is shut off by the moon's shadow.

EXERCISES

1. Briefly explain why the moon assumes different shapes or phases at certain periods of the month.
2. Draw diagrams showing eclipses of the sun and the moon. Explain why the former occurs at New Moon and the latter at Full Moon.
3. Why is an eclipse of the sun seen over a very limited area, while a moon's eclipse is visible over the whole hemisphere turned towards it ?

SECTION II.—THE STRUCTURE OF THE EARTH

CHAPTER X

THE CLASSIFICATION OF THE ROCKS

YOU must have noticed, both in your own neighbourhood and in other districts where you have spent your holidays, that the ground is not all level—that in some places there are gradual slopes, and in others steep slopes. In this and the succeeding chapters we shall learn why the earth's surface is uneven, why there are hills and valleys, tablelands and plains. We shall find that some of these irregularities are due to internal forces acting inside the earth, but that more of them are due to external forces, such as air, rain, and ice, wearing away the rocks unevenly.

A *rock* is any part of the earth's crust. It may be *hard* like granite, or *soft* as clay. It may be *friable*—that is, you may find the grains of which it is composed are not tightly cemented together, and pieces of it will crumble away easily in your hands. Some rocks, as chalk, are *porous*, or *permeable*, while others, such as slate, are *impermeable*; others again, such as limestone, are *soluble*, and may contain caves and mineral springs. These different properties cause rocks to wear away unevenly, and result in some regions in their being covered with a thin layer of soil, fit only for poor pasture, while in others they are covered with a great depth of fertile soil, good for the growth of crops.

In railway cuttings, along sea cliffs, or in open quarries, it is possible to see the depth of the soil, and of the sub-soil underneath, and below that the layers of stratified rock. The sub-soil is half-decayed rock.

Rocks can be divided into three classes: *Igneous, Stratified,* and *Metamorphic. Igneous Rocks* are due to the cooling of the earth's crust, and are found deep down, except where they have been brought to the surface by volcanic action, or where, after thousands of years, the rocks above them have been worn away. Where a molten mass cools very slowly, it forms crystals, and such igneous rocks as granite, having been formed at great depths, consist of crystals tightly packed together. Other igneous rocks, such as basalt, which are due to volcanic action, and have cooled much more quickly at the earth's surface, consist of a glassy substance in which crystals are contained.

> In Chapter III we learned that the Earth is a planet, and, from observations through the telescope of other planets in course of formation, we deduce that the Earth was once a gaseous mass derived from the Sun. During the process of cooling, it passed through a liquid state, then through a viscous condition like treacle; later a thin crust of solid matter was formed on the surface. Through this thin crust boiling liquids from the interior were forced out. These, by cooling and solidifying, added still further to the thickness of the crust. During all this time, heavy clouds of steam and water vapour formed an outer envelope, and, as cooling proceeded, this envelope later formed an outer covering which entirely covered the earth. Further cooling, inside the earth, caused the surface to be raised in some parts and lowered in others. Thus the land emerged from the water, while the water receded into hollows and formed the great oceans.

Stratified Rocks were laid down as sediments under water in nearly horizontal beds or layers; hence they are sometimes known as Sedimentary or Aqueous Rocks. You know that even the hardest rocks, such as are used for buildings and monuments, crumble away in time and fall into ruins, and that roads are constantly wearing away. After a shower of rain the loose grains of stone on a road surface are carried to the gutters and ditches, and eventually to the sea. The earth is several millions

of years old, and, during that time, waste material has been carried seaward by running water and laid down on the bottom of the sea in layers, thus forming clays and sands. Again, in the sea are millions of little living sea organisms ; the shells which protect their bodies sink to the bottom when these animals die. In this way deep beds of chalk and limestone, hundreds of feet thick, are formed, which in time become compressed and hardened into rocks.

Slow movements in the earth are constantly taking place ; rocks that were once below the level of the sea are now raised above it, and *vice versa.* Hence to-day we find chalk and limestone, sandstone and clay, forming rocks above sea-level.

Coal is another stratified rock. At one period of the earth's history part of the land was covered with dense forest. Gradual sinking of the earth's crust caused the trees to die, and they became buried in layers of sediment. These buried layers of vegetation were hardened and compressed into coal between other layers of rock, such as shale and limestone.

In other parts of the world great inland seas lost by evaporation the shallow water which covered them, and in this manner beds of salt were formed, deposited from the water that evaporated.

Underground water, often at a high temperature, is found below the surface of the earth. This water dissolves material from the rocks, and thus forms mineral springs. Mineral matter thus dissolved may be carried towards the surface through cracks in the rocks, and, the water becoming cooler, the mineral matter is deposited and veins of metallic ores are formed. Such mineral-bearing water passing through a loosely grained rock may cement the grains together; hence sandstones vary considerably in their hardness.

Metamorphic Rocks.—These are the earliest forms of stratified rocks, which have suffered considerable change owing to their being covered subsequently at great depths in the earth by other rocks. Thus great heat and pressure

at such depths have turned limestone into marble, and clay has similarly been turned into slate.

What you have learned in this chapter so far would lead you to suppose that all the igneous rocks are deep in the earth, overlaid by horizontal beds of stratified rock; but in later chapters we shall learn that volcanic and

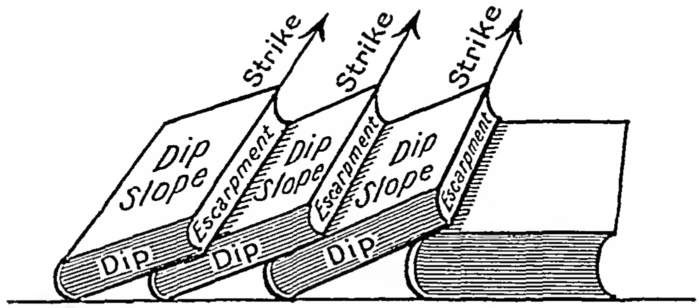


FIG. 15.—DIPS AND OUTCROPS.

other earth movements have contorted and twisted the rock strata, and brought deep-seated rocks to the surface, while slow movements of subsidence in some parts of the earth, and corresponding movements of elevation in others, have caused the strata to be tilted. In the south-eastern half of England the stratified rocks are sloped, each layer of older rocks dipping in turn under the next

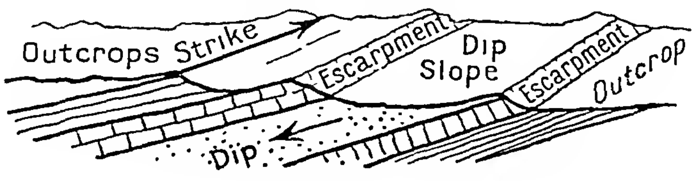


FIG. 16.—ESCARPMENTS AND DIP SLOPES.

younger layer. In the next two chapters we shall see how these different rocks, owing to their being worn away unevenly, cause hills and plains.

If you place a number of books as shown in Fig. 15, you will get some idea of how certain rocks are tilted in England and elsewhere. The left-hand book represents the youngest layer of rock, and each of the others in turn dips down under the subsequent layer. Notice that the

edges of the books form *Escarpments*. The direction of an escarpment across the country gives the *Strike* of the escarpment.

Some rocks develop cleavage planes. Slate, for example, can be split into thin sheets and thus used for roofing houses. Some limestones and sandstones can also be split into layers and used for paving stones. In quarries and cuttings you will notice also that joints are found in all rocks, and these enable the workmen to obtain blocks of stone for building and other purposes.

EXERCISES

1. Contrast igneous and stratified rocks. How were the former formed ?

2. Briefly describe how sandstone, limestone, and coal were formed.

3. Show how slow movements of elevation and subsidence have tilted rock strata, and caused different rocks to be found at the surface in different parts of the same country.

CHAPTER XI

THE ACTION OF AIR AND RAIN

THE *sun*, *air*, *rain*, *rivers*, and *ice* all help to wear away the rocks, and have slowly carved the earth into its present form. This wearing away of the rocks is called *Denudation*. This word means *laying bare*, and is so used because rocks on the surface are often worn quite away, so that rocks underneath are uncovered. The work of rivers and ice upon rocks is often spoken of as *Erosion*, and the action of the air and rain upon them as *Weathering*.

Action of the Air on Rocks

Notice a piece of unpainted iron which has been in the open air for a long time. You say it is rusty, and if left outside it will soon crumble away. In the same way air

acts on the rocks. In Cornwall the air acting on granite causes it to crumble and form china-clay.

You have seen dust being carried by the air on a windy day. The wind carries dust from the roads into our fields and gardens, and thus the roads become a little lower and the fields a little higher. In a small way the wind is moving part of the crust of the earth from one place to another, and altering the shape of the earth. In Northern China the winds blowing from sandy deserts during the winter carry to the plains large quantities of sand. In summer, grass springs up in this sand and holds it together. This has been going on for thousands of years, so that the plains of China are now covered to a depth of 1500 feet by this wind-carried soil, known as *Loess.*

In deserts the winds carry the sand along and pile it into great heaps, forming Sand-Dunes or hills of sand. In the south-west of France the wind carries so much sand in from the seashore, that, in order to prevent it being carried farther inland, masses of sedge grass and thick clumps of trees have been planted to form a barrier in the district called the Landes.

When on the sands at the seaside without your shoes and stockings, have you ever noticed that the skin of your legs has become very red and painful ? This was largely due to the wind, which had thrown thousands of grains of sand against your skin. Cottages near the sea and light-houses sometimes have their windows scratched and covered with small holes made by the sand particles. Some rocks are much softer than others, and these soft rocks will be worn away after hundreds of years by the sand grains, which are doing the work of little chisels, and helping to make the surface uneven.

Action of Rain on Rocks

On a wet day you will notice that the rain runs from the higher middle or crest of the road to the gutters on either side. The water in the gutter is muddy, because the rain has loosened the fine material in the road and

carried it to the gutters. If the rain is able to do this on a well-made road, it will be able to carry away much more material where there is loose soil or soft rock not covered with vegetation. If rain falls on a mixture of clay and large stones, it will wash away the clay between the stones, while that beneath the stones will be protected. In this way *earth pillars* are formed, but, directly these attain to any height they crumble away, the large stone falls to the ground, and another small pillar is formed.

If you have in your neighbourhood a bank of loose soil which has been standing there for some time, notice what the rain has done to it. You will see numerous channels or small valleys from which the rain has washed material and carried it to the land at the foot of the bank. What has happened on your bank of loose soil occurs in a much bigger way in other parts of the world. Millions of tons of loose rock have thus been washed away, and pillars of rock here and there prove what the height of the land once was before the rain washed the material away.

Of the rain that falls upon the ground, some is lost by evaporation, some runs off the ground and drains to the rivers, while much sinks into the earth. Many of the hill systems of England are composed of porous or permeable rock such as chalk, limestone, and sandstone. On such hills the water sinks through the porous rock till it reaches an impermeable layer, when it flows along the top of that layer until it finds a way out as a *Spring*. Suppose the impermeable bed is of clay, and that it is on a slope; then the water will make the clay slippery, and a large portion of the porous rock above may break away, and, sliding on the clay underneath, may form a *Landslip*.

As rain passes through the air, it dissolves out of it carbonic acid gas, and rain containing this acid is able to dissolve certain rocks like limestone if they are soft and spongy.

Sugar candy and loaf sugar are both made of the same material, but loaf sugar will dissolve easily, while candy will not—it is much harder. So rain does not act on all

limestones in the same way. In some places it sinks into a crack, and by dissolving the rock on either side of it, makes the crack wider. Much soil may be carried from the surface down such a crack. In harder limestone districts the water flows over the surface of a rock until it finds a crack, down which it runs, very slowly dissolving the sides of the crack. The limestone in this case being hard, the water does not dissolve much of it, and so goes to great depths before it is saturated with the limestone solution. Hence, in areas of hard limestone, caves are often formed at great depths. Rivers in limestone countries often flow along the surface until they come to such a crack, when they disappear underground, coming again to the surface later in their course.

EXERCISES

1. Name the chief ways in which air wears away the rocks.
2. Name the chief kinds of rock found in your district and state whether they are hard or soft, permeable or impermeable.
3. What does wind form with the material it carries away from the earth's surface ?
4. Describe the various ways in which rain wears away rock.

CHAPTER XII

CHANGES OF TEMPERATURE—ICE—GLACIERS

Changes of Temperature

TAKE a piece of heated glass and cool it suddenly by plunging it into cold water. It will fly to pieces. In a similar manner rocks are cracked and crumble to pieces. Heat causes rocks to expand, cold causes them to contract ; and, in countries which have very hot days and very cold nights, continual expansion during the day and contraction at night cause the rocks to crack in all directions and crumble into sand. In this way *Deserts* are formed.

The effect of extreme cold upon water is directly opposite to its effect upon rock. If you take warm water

and cool it, it will contract until near freezing-point, and then will commence to expand. Hence frozen water, or ice, takes up more room than the water did before it was frozen. Waterpipes burst in cold weather because of this; the water in the pipe freezes, and, because it requires more space, bursts the pipe. Now apply this to the rocks. We have found that water sinks into the cracks and pores in the rock. If the temperature falls below freezing-point, this water, being frozen, requires more space and forces the rocks apart, causing great cracks. Large pieces of rock are sometimes broken off, and fall from cliffs or mountain-sides.

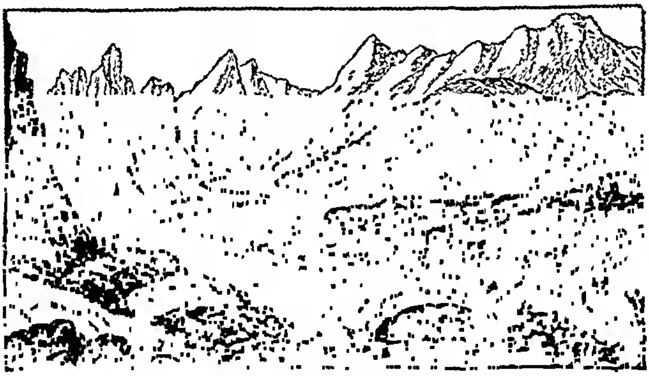


Fig. 17.—Glacier.

The Work of Ice

Above what is called the "snow-line" the heat of the sun is insufficient to melt all the snow that falls; hence there is an accumulation of snow on the higher lands of the earth, and the under-layers of snow are pressed into sheets of ice. The increasing weight of this ice forces it outwards in all directions, and it creeps slowly down the valleys as *Glaciers*. These glaciers erode material from the sides and the bed of their valleys. Material weathered from the sides of the valley also falls upon the surface of the glacier, and is carried along by it. In very cold countries, such as Greenland, the glaciers reach the coast without melting; there large pieces of ice break off, and

form icebergs, which go floating out to sea. More often, however, glaciers reach lower levels in the valleys which are warmer and melt, thus releasing large volumes of water, and giving rise to big rivers. Where a glacier melts, a pile of eroded material is deposited, forming a *Moraine.*

The Ice Age.—Thousands of years ago the climate of the British Isles was much colder than it now is. The seas were frozen; and the whole of north-west Europe, including England as far south as the Thames, was under a sheet of ice. Norway and Scotland were the birth-places of large glaciers which crept southward until they reached a temperature at which they would melt. These glaciers not only eroded and altered the shape of the land, but transported material from one part to another. Glacial clays and gravels together with morainic hills occupy much of the Thames Basin and the Baltic Lands. In other places lakes were formed by glacial action and rivers were altered in their volume and direction. A similar ice-sheet covered the northern half of North America, and was responsible for much of the surface conditions found there to-day.

EXERCISES

1. Why do people often paint the stonework of their houses?
2. Why on a frosty morning do you often find loose stones on the frozen road?
3. Rocks from Norway are found in the north-east of England. Can you suggest how they came there?
4. What is the cause of the sand in the desert?

CHAPTER XIII

THE WORK OF RIVERS

AFTER a heavy shower of rain walk along a road till you find a soft place in its surface. Notice that the water has cut little channels into this soft material,

and that many of these join together and form a large stream. The material from these channels has been carried to the gutter, and has made the water there muddy. These channels are river valleys in miniature, and all rivers cut valleys in this way by wearing away the rocks. Every river is busy making a valley, and the amount of soil it wears away depends upon the kind of rocks over which it flows.

The Sources of a River.—We saw in the previous chapter how the melting of glaciers releases great volumes of water, giving rise to some of the largest rivers of the world. Other rivers owe their origin to the natural drainage of sloping land, while some derive their headwaters from springs issuing from the ground.

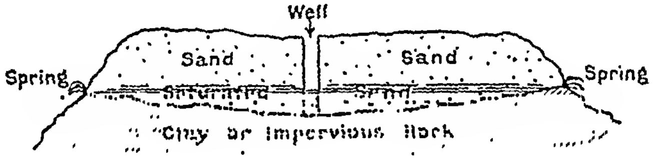


FIG. 18.—SPRINGS AND WELL.

Springs.—Rain falling on porous rocks sinks below the surface until it reaches an impermeable rock, and, being unable to penetrate the latter, saturates the pores above until it can find an outlet. In the chalk country of England the rain sinks through the porous chalk, and comes bubbling out at the foot of the hill as a *surface spring*, above the outcrop of the impermeable clay below it. Fig. 18 shows how to make a model of such a spring.

River Valleys.—If you follow the course of a river, you will notice that its valley is steepest in its upper course, and that, as it descends from the higher ground to the plain, its slope becomes more gentle. In dry countries with little rain, the sides of the valley are vertical, as shown in Fig. 19, but in wet countries the rain and the atmosphere denude the sides and cause them to crumble away, thus making gradual slopes and a wider valley. The width of the valley also depends upon the

kind of rock through which the river cuts its channel. The valleys of rivers flowing through soft rocks have more gently sloping sides than those of rivers which carve their way through hard rocks.

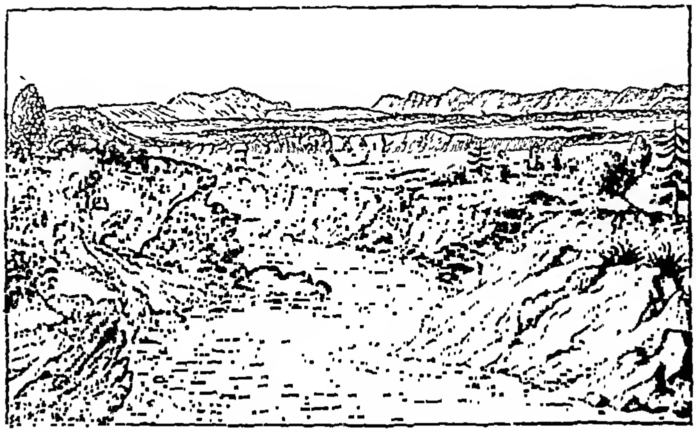


FIG. 19.—RIVER GORGES.

The amount of material carried down by a river depends upon the slope of the valley. If the general slope of the land is steep, then the valley will be steep, and the water will flow very quickly. A river in such a valley takes a straight course, and tears away the obstacles in its path. As it carries pieces of rock along, it dashes them one against the other until all their rough corners are knocked off. As the river leaves the higher ground and descends to the plain, it moves more slowly, and so cannot carry the large stones, which it now drops in its bed. If you walked along a river bank from source to mouth, you would notice that the coarser material was dropped first, and that the finest material was carried to the river mouth.

As the river's energy is decreased when it reaches lower levels, and as much of that energy is utilised in carrying eroded material, it cannot at that later stage cut its way through difficult obstacles, but winds and meanders round them. Thus bends are found in the middle and lower courses of most large rivers. Fig. 20 shows such a bend in the River Rhine. On the outside of the bend the river flows fast, because it has a great distance to cover, but, on the inside, the water hardly moves at all. Hence you will notice that, on the outside of the curve, there is a steep bank which the river is under-

cutting, while on the inside of the bend there is a low plain, formed of alluvium, or water-borne soil, deposited by the river.

Rivers cut V-shaped valleys, the slope of the sides of the V varying according to the nature of the country through which the river flows. Glaciers, on the other hand, cut U-shaped valleys, such as were formed in Switzerland during the Ice Age. *Suspended* or *Hanging Valleys* are formed by streams between the mountain peaks that stand on the higher ground above the almost perpendicular sides of these troughs. From these hanging valleys the streams descend to the U-shaped trough

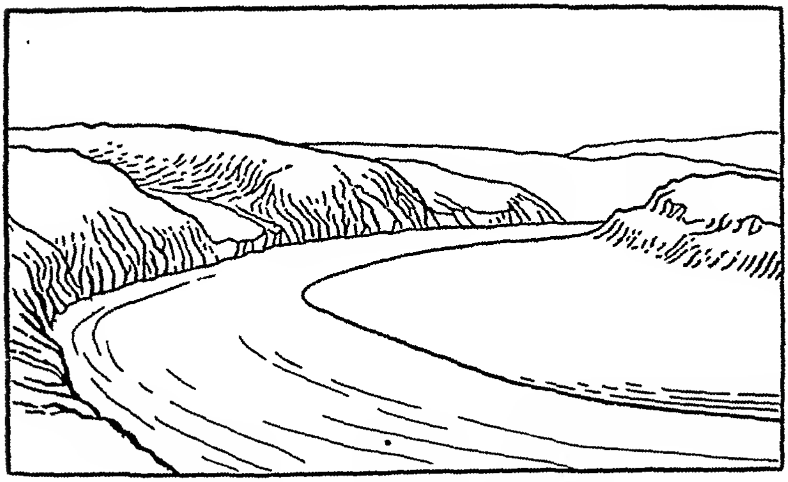


FIG. 20.—A BEND ON THE RIVER RHINE.

below by cascades. The *Fiords* or *Sea Lochs* of Norway and western Scotland are drowned glacial valleys, with very steeply sloping walls of mountain; but the *Rias* of south-west Ireland are drowned river valleys, and have their sides more gradually sloped.

Tributaries and River Basins.—A river, as it flows to the sea, is joined by other streams which have drained land on either side of the main stream. These streams are known as *Tributaries* or *Affluents*, and the meeting-point of these tributaries with the main stream is known as the *Confluence*. As you face the mouth, the tributaries on your right hand are those of the *Right Bank*, and those on your left hand are the *Left Bank* affluents.

The basin of a river is the whole area which a river and its tributaries drain. Map 2 shows the basin of the Thames. Look carefully at the map and notice the tributaries on both the left and right banks, and the hill systems which they drain.

A line traced on this map to separate the drainage basin of one river from adjoining basins would mark a *Divide, Water-Parting,* or *Watershed.* In some places, as between the Upper Thames and the Lower Severn, the water-parting is very Definite, but in others, as between the Cherwell tributary of the Thames and the Ouse, the water-parting is very Indefinite

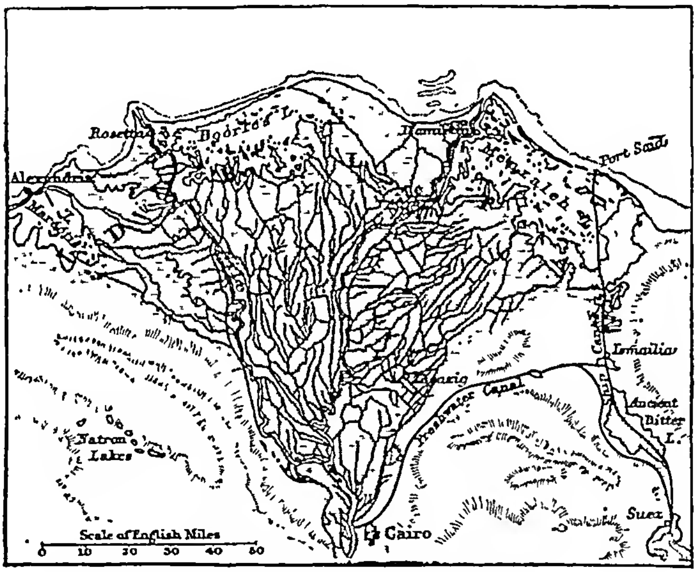
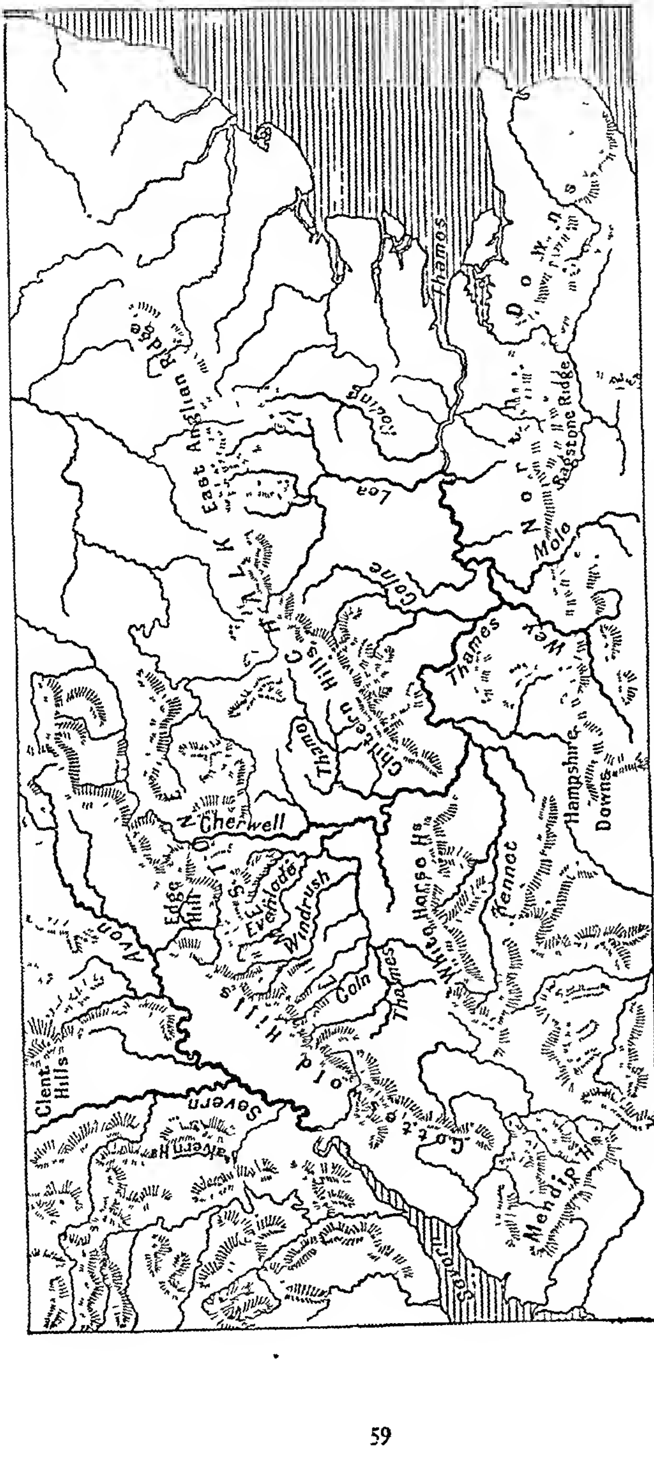


FIG. 21.—THE DELTA OF THE NILE.

Flood Plains.—As the river proceeds towards the sea, we know that its energy decreases and it cuts a more shallow bed. Such a river, when swollen by heavy rains or melting snows, is liable to overflow, and in so doing deposits silt on the adjoining land. The area thus liable to flood is known as the *Flood Plain.* The northern plain of India is the flood plain of the Ganges and Indus, and the Plain of Lombardy is the flood plain of the Po. Such flood plains are exceedingly fertile, and the agricultural peoples who settle there make embankments to



MAP 2.—THE BASIN OF THE THAMES.

keep the floods within bounds, and irrigation canals to convey the water to where it is required.

During the period of flood a river may cut a new course for itself, and, when the flood subsides, may forsake its old bed, or two or more channels may be formed.

A river flowing very sluggishly may build up sand-banks in its bed, splitting into many channels and rendering navigation difficult. A similar deposit at the river mouth leads to the formation of a *Delta*, so called from the Greek letter Δ. When the tide enters the river mouth and conveys the waste material out to sea, an *Estuary* is formed, but, if the tides rush past a river mouth, such material may be piled up in the form of a *Sandbar*.

EXERCISES

1. Describe the destructive and constructive work of a river.
2. Define River Basin, Water-Parting, Flood Plain, Confluence. Give examples of each.
3. Make a model of a spring and a well by taking a large tray and covering it with a layer of clay hollowed in the centre. Cover this with five or six inches of sand. Insert a pipe down the centre for a well. Pour water slowly on your model, and observe the result.

CHAPTER XIV

LAKES AND WATERFALLS

LAKES occupy hollows in the land, just as puddles are found in the road after every shower of rain. Dry hollows are only found where there is an insufficient rainfall, or where the underlying rock is porous and allows the water to percolate through it. In some dry areas rivers occupying a *Basin of Inland Drainage* flow to a lake which has no outlet to the sea. Such a lake maintains its level through loss of water by evaporation.

In wetter regions lakes have usually sufficient volume of water to force an outlet to the sea. The water of inland basins, owing to the great amount of evaporation, is salt, but that of lakes which have outlets is fresh.

Glacial action, by depositing material as a dam across a valley, may lead to the holding up of water behind it until the water reaches the level of the top of the dam, and thus to the forming of a lake. Lakes sometimes occupy the craters of extinct volcanoes; and lava flows, by damming the entrances of valleys, have also formed lakes. *Volcanic action*, by lowering the level of an area of land relatively to the surrounding district, may provide a hollow for a lake to occupy, as in the case of Lough Neagh in the north of Ireland.

In Ireland and in other parts of the world slow-flowing rivers, by dissolving the rock substances along their banks, have broadened out into large lakes on parts of their courses.

In the nearly level plains of the Nile and Niger, in the middle sections of their basins, the river beds are shallow. The rivers therefore overflow their banks during the wet summer, and marshy lakes are formed, which disappear during the drier winter season.

A lake through which a river flows may act as a filter, as a regulator of the flow, or as a reservoir to that river.

The Rhine flows from the Alps as a turbulent, muddy stream. Its current is checked when it reaches Lake Constance, and it deposits there material forming a *Lake Delta*. It leaves the lake as a clear, placid stream.

The Nile flows for 1800 miles across the desert, and would dry up long before it reached the sea, were it not for the reservoir of Lake Victoria. This large lake, nearly equal in area to Scotland, lies in a region of heavy rainfall, and its waters accordingly enable the Nile to maintain its flow throughout the year.

Waterfalls.—The most frequent cause of waterfalls is the unequal hardness of the rocks through which a river is carving its valley, *e.g.* Niagara Falls. In Fig. 22 it is shown how the outcrop of a hard limestone rock wears

away more slowly than the soft shales below it, thus causing a waterfall. As the underlying shales are cut away, the harder limestone may break off, and then undercutting will commence again. In this way a waterfall gradually works its way backward towards the source of the river.

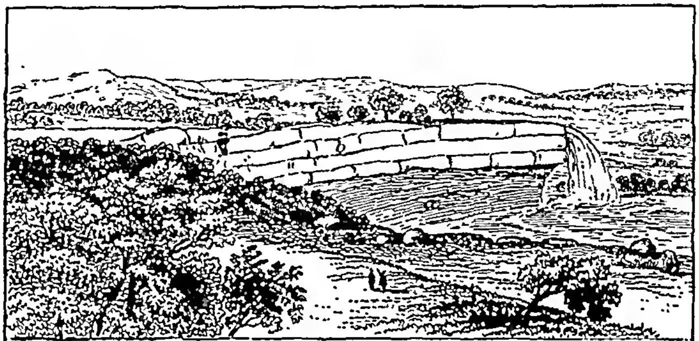


Diagram section of a Waterfall

a Soft shales which decompose more rapidly than the rock above
b Hard limestone which projects beyond the soft rock below and gives rise to the perpendicular fall

Fig. 22.—Waterfall.

Waterfalls also occur where an old hill ridge has been buried under more recent deposits. As the river cuts through the softer deposits, it reaches the harder rock, and rapids are formed, *e.g.* the Cataracts of the Nile. In New England former ridges were buried under glacial material during the Ice Age, with the result that the rivers of that region to-day contain many waterfalls, and the power derived from them is used in manufacture.

In some localities, as on the Atlantic coast of the United States, soft sediments have been built up along the margin of an old rock mass. At the junction of the hard and softer rock masses the rivers form waterfalls. The "Fall Line" is the edge of this old rock margin; and the towns which have sprung up on the rivers' banks at the Fall Line owe part of their importance to water-power.

Glacial action, by forming U-shaped troughs below the original level of Alpine valleys, causes the beautiful cascades, typical of Alpine scenery.

The edges of resistant block plateaux cause waterfalls, where rivers tumble over their steep rims, *e.g.* the Victoria Falls on the Zambesi River of South Africa.

EXERCISES

1. What is a Basin of Inland Drainage ? Why are its waters salt ? In what areas do we find these basins ?
2. Name some of the causes of waterfalls. Give examples in each case.
3. What are the advantages of a lake to the river which flows through it ?

CHAPTER XV

FORCES WORKING INSIDE THE EARTH

WE have seen in the previous chapters how the sun, air, rain, rivers, and ice all do their part in giving to the land surface its present shape. We have learned that many of the inequalities in the surface are due to the nature of the rocks, and that many of the mountain and hill systems are due to the resistance to denudation offered by hard rocks as compared with soft clays. Permeable rocks, such as chalk and limestone, often form hills to-day, because they have offered little resistance to water, and allowed it to pass through them.

> The slow movements of elevation and subsidence, mentioned in an earlier chapter, also affect the work of denudation, especially denudation by rivers. After many thousands of years a land surface may have been worn down to a gradual slope, across which rivers flow sluggishly to the sea. Later, movements of elevation may raise up such lowland plains as plateaux, thus causing the rivers to flow swiftly to the sea once more. Hence the whole process of erosion begins afresh on the land surface thus re-elevated.

In addition to these slow movements of elevation, there are more violent movements due to the great heat and pressure in the interior of the earth, which twist,

contort, and fold the rocks in different forms. It should be remembered that the earth's actual crust is very thin compared with the size of the earth, and that it is upon this outside crust that these internal movements have their effect. In this chapter we shall see the results of the action of these internal forces upon the earth's surface.

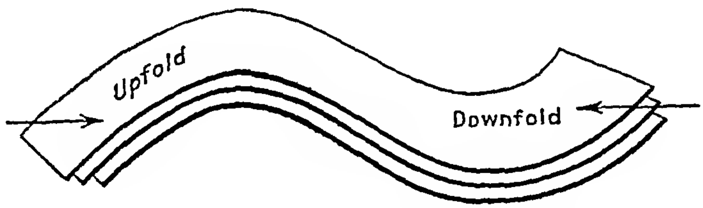


FIG. 23.—UPFOLD AND DOWNFOLD.

The Folding of the Rocks

Internal earth movements and the great heat below the earth's crust have caused layers of rock to fold. Sometimes this has taken the form of simple *upfolds* and *downfolds*, as shown in Fig. 23, but more often there is an *overthrust*, as in Fig. 24, as the result of lateral, or side, pressure. To such rock folding are due the great moun-

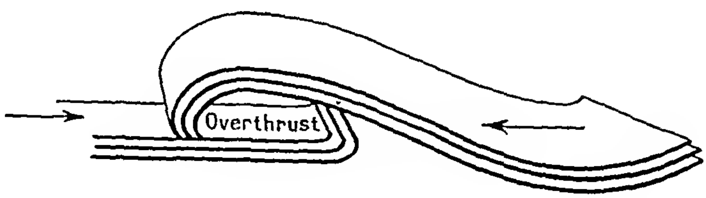


FIG. 24.—OVERTHRUST.

tain ranges of the globe. On your atlas map of the world trace the mountain folds which run through southern Europe from the Pyrenees to the Caucasus, and are continued as far as the Himalayas in Central Asia. Similar folds are represented by the Rockies in North, and by the Andes in South America.

Owing to the intense strain on the top of such a fold, great cracks take place, which allow the action of air, rain, and ice to wear the sides of the cracks away. In

the downfolds the rocks are compressed, and are thus able, if exposed at a later period, to withstand denudation. In countries, such as Scotland, which have been much subject to denudation, the direction of the strata sometimes suggests that rocks which to-day appear as mountains once occupied the bottom of downfolds as valleys (see Fig. 25).

Hard *Resistant Blocks*, which now form *Block-Plateaux*, have in most cases been able to resist folding, and by such resistance have caused diversion of the course of mountain folds on either side. In other places, under the pressure raising the mountain folds, such a block has split instead of folding, and formed a *Rift Valley*.

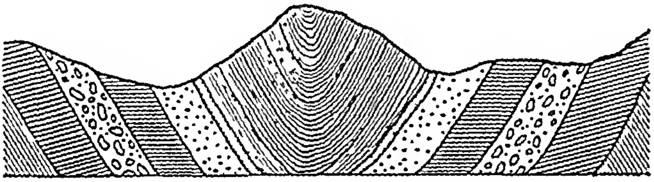


FIG. 25.—DIRECTION OF STRATA IN MOUNTAIN SUMMIT.

A study of the map of Asia shows that the Block-Plateau of Tibet has diverted the folds of the Kuen-lun Mountains and the Himalayas, and that a line of folds runs north of the Block-Plateau of Iran as the Hindu Kush and Elburz Ranges, while the Sulaiman and Zagros Mountains border its other sides. In the west the Block-Plateau of Asia Minor separates the Pontic Mountains, which form the northern rim of the peninsula, from the Anti-Taurus and Taurus Ranges.

The Rift Valley type of structure is well shown in the Red Sea. This huge Rift Valley is continued northward by the Jordan valley into Syria and southward into the Plateau of East Africa. Similar Rift Valleys account for the formation of the Central Lowlands of Scotland and for the middle valley of the Rhine.

Volcanoes and Earthquakes

Yet more violent disturbances of the rocks than those which produce mountain folding cause volcanoes and earthquakes, the latter sometimes forming visible cracks in the surface of the earth, as in Japan, and at other times

causing an outflow of molten rock or lava, through a pipe or fissure deep-seated in the earth.

A volcano is a hill or mountain formed of material which has been forced up, either in a molten state, or in fragments, from below the surface of the earth. A funnel-shaped crater extends like a great chimney through the centre of the volcano, and, when the volcano is "active," dust, ashes, stones, and molten rock or lava are thrown out from the crater. In some volcanoes the craters are sealed up with molten rock which has cooled and solidified, and we then call them *extinct volcanoes*; in others an eruption has not occurred for a long time, although the crater is not thus sealed; these are said to be *dormant*, or sleeping. Such volcanoes may become active at any time.

Before a volcanic eruption occurs, rumbling sounds come from the interior of the earth, and small earthquake

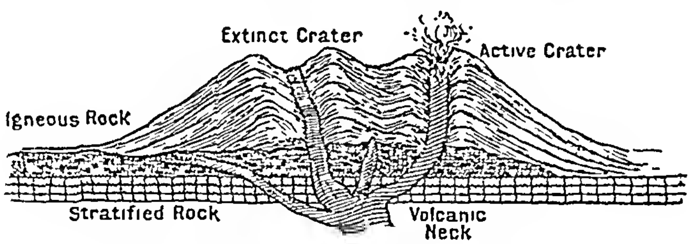


FIG. 26.—VOLCANO, SECTION THROUGH.

shocks are felt. These rumblings are followed by great jets of steam, forced high in the air; at the same time poisonous gases are given out, which kill all the plants, and often animal life as well, for miles around. The gases are succeeded by clouds of red-hot stones and ashes. The finer ash from a volcanic eruption is often carried miles away by wind before it is deposited on the earth. Later, the lava or molten rock is forced from the interior, and this flows slowly down the mountain-side.

Earthquakes

Earthquakes, like volcanoes, are caused by forces acting inside the earth, but, unlike them, do not force out

material from the interior. Instead, they cause the earth in places to rise and fall again, in a manner similar to that in which the surface of a thick liquid acts when it has nearly reached boiling-point. Earthquakes do great damage, altering the surface of the ground, overthrowing buildings, and breaking bridges and railways.

EXERCISES

1. Explain why the chalk and limestone rocks of England form hills, while the clay rocks form plains.
2. Name some of the great folds of the earth's surface. State how they were formed.
3. What is a Block-Plateau? Name some of the chief Block-Plateaux in the world.

SECTION III.—THE WATERS OF THE EARTH

CHAPTER XVI

THE OCEANS—DEPTHS AND TEMPERATURES

The Oceans

NEARLY three-fourths of the globe is covered by the sea. The world can be divided into halves, so that the greater part of the Land is in one hemisphere and the greater part of the Water in the other. Fig. 27 shows the Land and Water Hemispheres. Notice that the British Isles are in the centre of the Land Hemisphere, and New Zealand is the centre of the Water Hemisphere.

Find on your map the five oceans, viz. the *Atlantic Ocean*, between the shores of Africa and Europe on the east, and North and South America on the west; the *Pacific Ocean*, between the eastern shores of Asia and

Australia, and the western shores of North and South America; the *Indian Ocean,* which is bounded on the north by Asia, on the east by Australia, and on the west by Africa; the *Arctic Ocean,* which lies round about the North Pole; and the *Antarctic Ocean,* which washes all the shores of Antarctica.

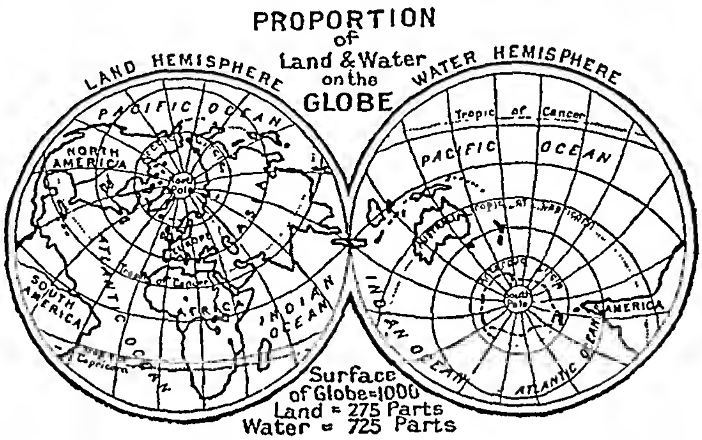


FIG. 27.—LAND AND WATER HEMISPHERES.

The Atlantic, forming an S-shaped curve, has its shores roughly parallel. On the north three wide channels open to the Arctic Ocean: (1) between Europe and Iceland, (2) between Iceland and Greenland, and (3) between Greenland and Baffin Island. Its area is roughly 33,000,000 square miles.

The Pacific extends from the Arctic Ocean to the Antarctic as the Atlantic does, but its shores are not parallel. Shallow Behring Strait, where Asia most nearly approaches North America, connects it to the Arctic Ocean, and from that point the two continents recede, so that the ocean is widest at the Equator. Its area is 55,000,000 square miles.

The Indian Ocean differs from the other two oceans in having a land mass on its northern border. Its area of 17,000,000 square miles is roughly equal to half that of the Atlantic.

Ocean Depths and Temperature

Shallow seas, less than 100 fathoms deep, surround the coasts of many of the continents. The "*continental*

shelves," which form their beds, are connected in structure with the adjoining mainlands. A study of the atlas will show that wide coastal plains are usually bordered by wide continental shelves, and that, conversely, where there is a steep ascent to lofty mountain areas from a narrow coastal plain, there is a narrow continental shelf, bordered by great ocean depths. A knowledge of the ocean depths beyond the coasts has only been obtained during the last two centuries. Deep-sea sounding instruments enable us to obtain correct information not only of the depths of the ocean, but also of the material on its floor, while thermometers give us particulars of ocean temperatures.

Terrigenous Deposits, or those derived from the denudation of the land, are found near the shore in shallow sea areas. The *Pelagic Deposits* found at ocean depths consist of red clay of volcanic origin, and of a number of oozes, formed of the minute skeletons of plant and animal organisms.

In the *Atlantic Ocean*, deep-sea soundings have revealed the presence of a submarine ridge running centrally from north to south. On either side of this ridge south of 50° N. are great ocean depths, but across the northern section called Telegraph Plateau, where cables have been laid connecting Europe to America, relatively shallow water extends from the British Isles to Labrador. Notice that the *Azores* in the North Atlantic, and *Ascension* and *St. Helena* in the South Atlantic, are oceanic islands built on this submerged Atlantic Rise.

In the *Pacific Ocean* the courses of the submerged ridges are more irregular, except for one which links Central America to Antarctica. In the Southern Pacific are many submerged ridges, on which are found groups of islands of volcanic or coral formation.

In the *Indian Ocean* one submarine ridge runs southward from Ceylon to the Tropic of Capricorn; upon another the oceanic islands of the Seychelles and Mauritius are built up.

Ocean Temperatures.—Deep-sea thermometers, attached to deep-sea sounding apparatus, enable records of temperature to be taken at any depth. From

records thus obtained it is found that the temperature of sea water in tropical areas drops rapidly in the first 500 fathoms, but after that decreases very slowly until it reaches 40° F., which is a constant temperature for all the waters of the globe at great depths. From this it can be deduced that the effect of the sun's rays rapidly decreases below the surface, and below 500 fathoms is hardly felt at all.

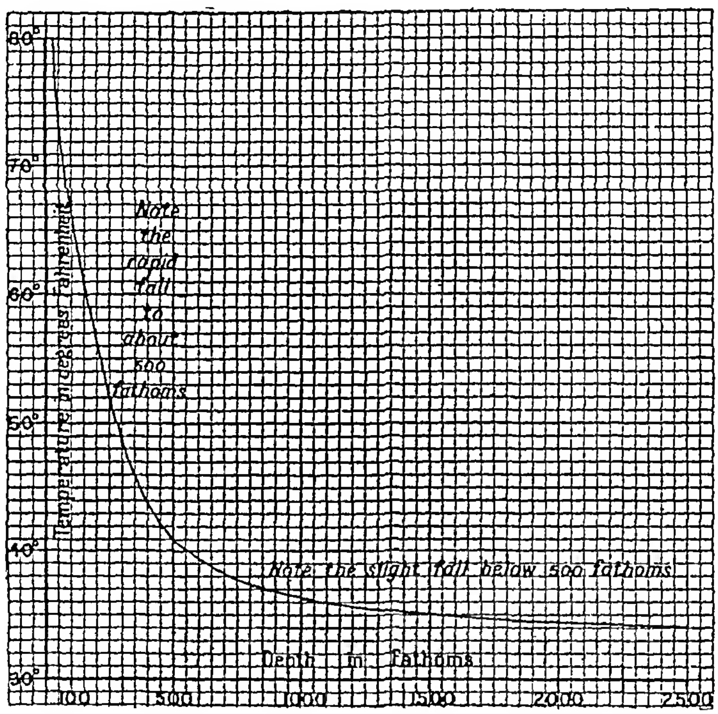


Fig. 28.—Deep Sea Temperatures.

The sea freezes at a temperature of 27° F. or −2·5° C. Hence in polar regions the surface water becomes frozen, although that at great depths never freezes. Great *ice-fields* are formed, and, when these break up in warmer weather, *ice-floes* are carried from them by the drift currents. Ice-floes, when pressed close to one another, unite to form *pack-ice*. It was this pack-ice which formed the greatest barrier to Arctic exploration.

Composition of Sea Water.—The sea is salt because the rivers, in their drainage of the land, dissolve salts from the rocks in very minute quantities. As sea water

evaporates, these salts are left behind, and it is this accumulation of years that causes sea water to be salt. Many of the rarer salts are used to form the shells and skeletons of the sea organisms, which accounts for the larger proportion of common salt that remains.

The Work of the Sea

The air obtains its moisture chiefly by evaporation from the sea, and this moisture is returned to the earth in the form of dew, rain, snow, etc.

If the sea were taken away, all forms of rain would cease, and there would be no water to feed springs and rivers. These would therefore dry up. There would be no dew to freshen plants and the surface of the earth. There would be no snow to cap the tops of our highest mountains, and no great glaciers and icebergs. All forms of moisture would come to an end, and animals and plants would die.

EXERCISES

1. Describe the Atlantic Ocean, its coasts and sea depths.
2. Describe the Pacific Ocean. Show how it differs from the Atlantic and Indian Oceans.
3. What do you know of ocean temperatures? Explain what would happen if the constant temperature at 1000 fathoms were 10° F. less than it is.
4. Define continental shelf, ice-floe, and pack-ice.

CHAPTER XVII

THE WORK OF WAVES AND TIDES

Waves

THOSE of you who have been to the seaside must have noticed the waves. On a very calm day these were scarcely to be seen, but on a rough day the waves formed high ridges or crests and deep hollows or

troughs, and the crests of the ridges were covered with white foam. Waves, we may therefore deduce, are caused by the winds.

In deep water, far from the coast, a wave is only an upward and downward movement of the water, which is not carried along. If you want to prove this, take a cork or piece of paper, and, when out in a boat, drop it over the side. The cork will go up and down with the waves, but, because the water is only moving up and down, it will not be carried away, but will stop in the same place.

Near the shore, however, the lower part of a wave is stopped by the bed of the sea, and the crest topples over in a curve of foam.

You can make these different waves for yourselves. Take a clothes line, and, holding one end of it in your hand, sharply jerk it until a number of waves travel along the

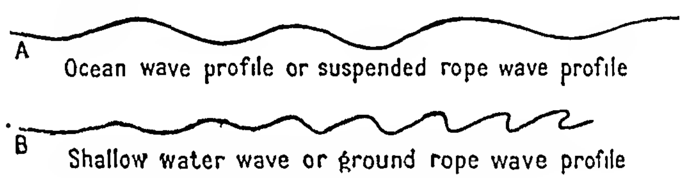


FIG. 29.—WAVE PROFILES.

rope. The rope itself does not move onward, but the wave passes right through the rope, causing crests and troughs. If you let the other end of the rope rest on the ground, you will notice that the bottom of each wave is stopped by the ground, and the top tends to tumble over. Fig. 29 shows two such waves. "A" represents a wave in a rope which does not touch the ground. This is similar to the deep ocean wave. "B" represents a wave in a rope touching the ground, and is similar to a wave in shallow water.

Wave Erosion

The waves dash against the land, especially in stormy weather, and thus produce great changes in the shape of the coast. In some places, where the sea is bordered by cliffs of solid rock, stones are hurled by waves against the bottoms of the cliffs, and these, together with the force of the waves, gradually hollow out the rock at the foot.

This goes on until the overhanging piece of cliff at the top breaks off because of its great weight. This is carried away by the sea, and the waves start afresh to wear away the bottom of the cliff. In this way the sea gradually destroys the coast. In other places, where the coast consists chiefly of hard rocks, the sea dashes up against these with little effect, but, wherever there is soft rock, the sea will wash it away, leaving outstanding those pillars of hard rock which can withstand the action of the waves.

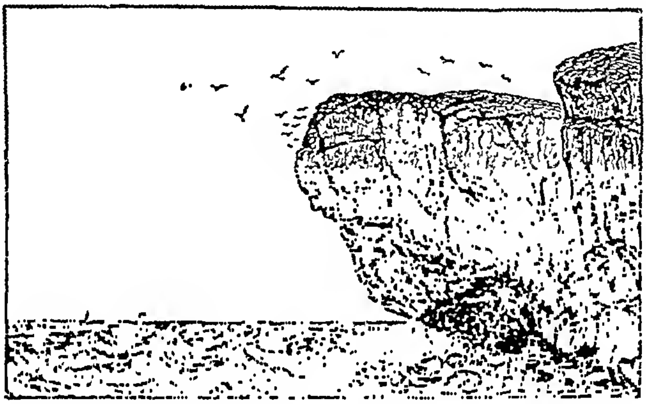


FIG. 30.—SEA ERODING A CAVE.

If you look at the pebbles on a beach you will notice that they are all rounded. Examine the sand on the seashore under a magnifying glass, and you will see that the little stones of which it consists are rounded. This is due to the waves, which dash the stones against each other and break off their sharp corners.

Tides

When at the seaside you must have noticed that the water is not always at the same height. During one part of the day the water gradually rises, and comes nearer and nearer to the shore, and we say that the tide is coming in. After a time it reaches its highest point, and then begins to go out. When the tide comes in we say it *flows*, and when it goes out we say it *ebbs*. The tide flows

twice and ebbs twice in a little more than twenty-four hours.

The next time you are at the seaside, watch some post in the sea, such as a support of the pier, and notice the highest point reached by the tide each day. You will see that the height of the tide gradually increases each day until the water is very high, and then it gradually becomes less each day. If you are lucky enough to be able to stay at the seaside for a month, you will see the tide reach its highest point twice, and will observe that, during the week after each of these very high tides, it rises less high each day, so that twice during the month the water will rise very little. The highest tides during the month are called *Spring Tides*, and the low tides, which occur a week later, are known as *Neap Tides*.

Tides are caused by the sun and moon acting on the waters of the earth.

Tides do an important work in altering the outline of the coast. In some parts where the tide is strong, the sea, dashing against the cliffs, undercuts them, and large pieces break off and are carried away to sea. In such cases it is necessary to erect sea walls to prevent the tides encroaching still farther on the land. Material carried by the tide is dropped on the continental shelf and causes sandbanks; elsewhere such material is deposited along the shore, building the land out seawards and in some parts forming low capes. When the tide rushes up a river mouth it carries away when it ebbs the silt brought down by the river, and an *estuary* is formed. In the absence of such scouring action by the tide the river builds up a *delta* with this silt.

Notice that, as the tidal waves of the Atlantic and North Sea advance into the narrowing and shallowing English Channel, the water becomes piled up, and higher tides are experienced than on the open ocean coasts. Similarly there is a difference of forty feet between the levels of the water at high and low tide at Cardiff as compared with ten feet at the mouth of the Bristol Channel. Water running up such a narrowing estuary as that of the Severn forms a *Bore*. Where the tidal wave rushes through

narrow channels dangerous *races* and *eddies* are formed, as in the Pentland Firth and in the Maelstrom near the Lofoten Islands off Norway.

Tidal currents are an advantage to shipping because, in addition to scouring the harbours, they assist ships to enter river mouths on the flood tide and to leave them on the ebb tide. The higher level of the water at high tides enables vessels to sail farther up estuaries than they can normally do.

As the direction of *Ocean Currents* is determined by Winds, we will study them later in Section V, after we have learned something of the Wind Systems of the World.

EXERCISES

1. Prove that a wave is not an onward movement of the water.

2. Show the effects of waves upon the coast.

The following can only be worked by pupils who live near the sea or on the tidal estuary of a river. Those who live away from the sea should complete them the first time they visit the seaside.

3. When the tide is out, notice where the biggest stones are found and where the finest mud or sand.

4. Notice carefully the time of high tide on two succeeding days. What is the difference in the time ?

5. Notice carefully, by observing some post in the sea, the highest point reached by the water on two succeeding days. Was it higher or lower the second day ?

6. Take daily observations of the time and height of the tide for one month. Notice the difference in the times, and also in the heights each day.

7. Is the pier at the seaside resort you are visiting long or short ? Give reasons why.

SECTION IV.—THE REPRESENTATION OF THE EARTH

CHAPTER XVIII

MAPS, SCALES, DISTANCES, AREAS

A **MAP** or Plan is a representation of the earth, or of part of it, drawn to scale, so that it is possible to obtain from it particulars of direction, distance, and area. **Scale** is the relationship between the actual size and the size on the map, and each part of the plan is drawn in this definite proportion.

If you place a book on a piece of paper and draw lines round it, you have a plan of the book drawn to its actual size, but it would be impossible to draw a plan of your classroom its actual size on a piece of paper. Draw a plan of your room by first measuring the long sides. If you find these are 24 feet in length and the longest side of your paper is only 8 inches, you might choose a scale of $\frac{1}{4}$ inch to 1 foot, that is, $\frac{1}{4}$ inch will represent 1 foot of actual length. You can now complete your plan by measuring all the necessary distances and drawing these to scale. A picture of this room would look very different from the plan you have drawn. The desks in the front of the picture would appear much larger than those farther away, but in the plan everything must be drawn in proportion to its actual size.

With the help of your teacher it may next be possible to draw a plan of the school, but here you will need a different scale. If the longest wall is 120 feet, you will need to draw your plan to a scale of 1 inch to 20 feet. You should also try to draw a plan of the main streets near your school. It may be impossible actually to measure these, but you can judge the distances by the time it takes you to walk along them. It is usual to draw a plan or map with the north at the top. You should therefore find out which direction is the north,

either by a compass or by the position of the sun, and make your roads follow their proper directions. Fig. 31 shows such a plan drawn to a scale of 3 inches to 1 mile.

Map 3 (p. 79) shows a section of the Ordnance Survey Map of the Isle of Wight. It is drawn to a scale of 1 inch to the mile, and, if we measure the distance between Cowes and Newport, we shall find that it is 4 inches and therefore *represents* 4 miles. If you look at the maps in your atlas you will see that they are nearly all the same

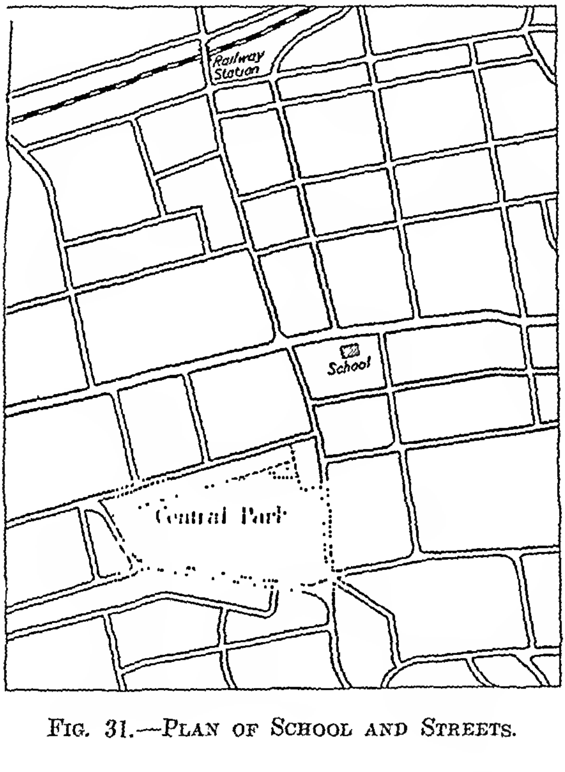


FIG. 31.—PLAN OF SCHOOL AND STREETS.

size, but they do not represent similar-sized areas of country, because they are drawn to different scales. Find from a map of England and Wales in your atlas, firstly, the scale of the map, secondly, the distance between London and Crewe, and then work out the actual distance between the two places. In a similar manner obtain from a map of Europe the actual distance between London and Constantinople.

It is usual to draw a scale somewhere on the map showing the relationship between the actual measure-

ments and the map measurements, but sometimes this relationship is shown by a *Representative Fraction*, in which the numerator and denominator show the ratio between the two measurements. In other words, the numerator equals the map measurement and the denominator equals the ground measurement in the same unit of length.

In Map 3 the scale is 1 inch to 1 mile, thus the representative fraction will be $\frac{1}{63360}$, because 1 inch on the map stands for 63,360 inches of actual country. From the scales given for your atlas maps of England and Wales and Europe find in each case the representative fraction.

From the scale we can not only obtain actual distances, but we can also determine areas.

Fig. 32 shows a map of Essex traced on a piece of squared paper. The map from which this was taken was drawn to a scale of 1 inch to 60 miles. If 1 inch stands for 60 miles, then 1 square inch stands for 3600 square miles, and, as there are 100 small squares in a square inch, each small square stands for 36 square miles. Counting the number of squares inside the outline we find they total 50. Thus the area will be 50 squares $\times$ 36 = 1800 square miles = approximate area of Essex. In a similar manner the student should find the area of Spain and Portugal from the atlas maps of Europe.

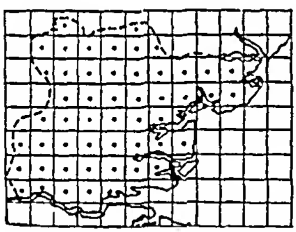
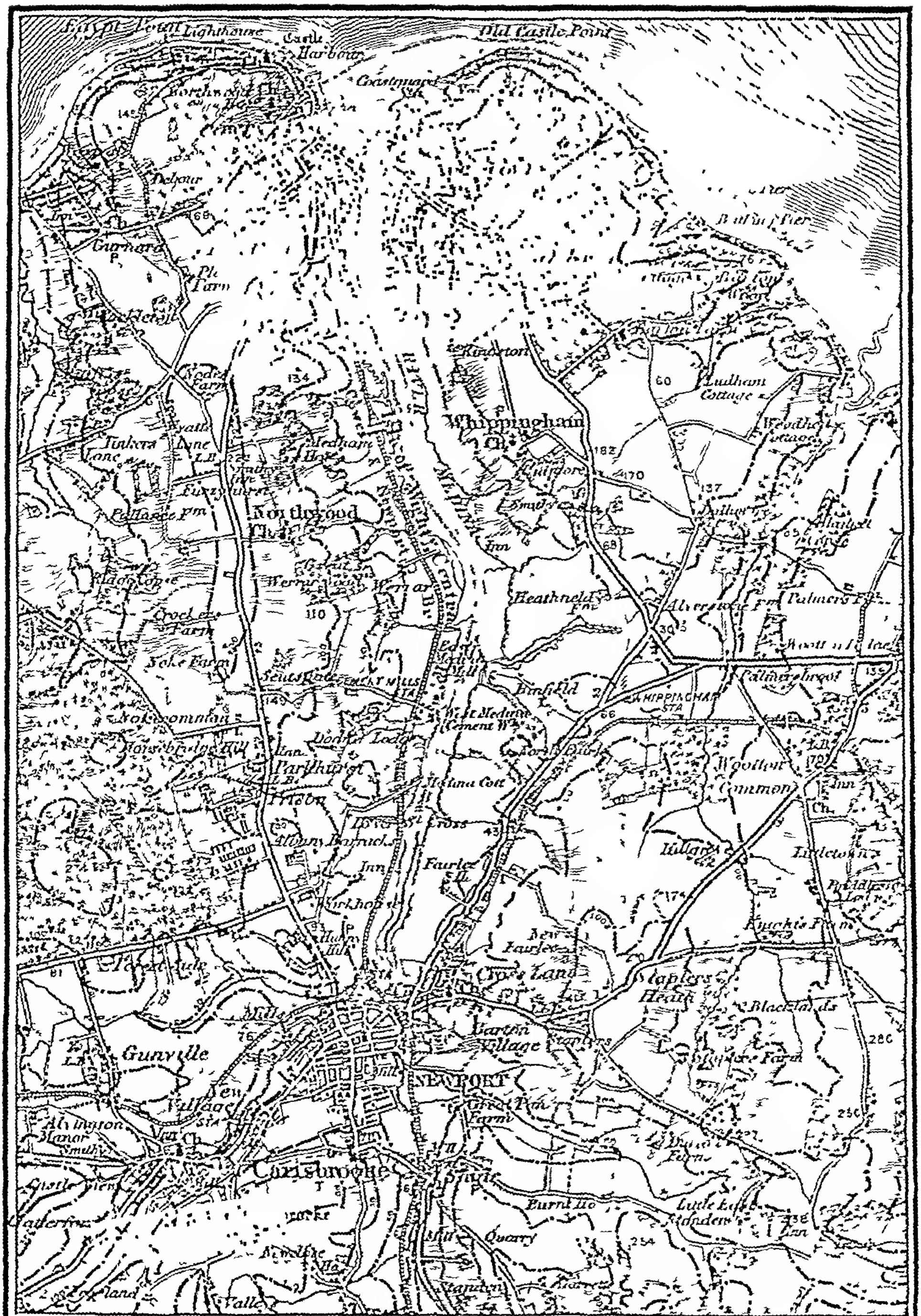


FIG. 32.—AREA OF ESSEX.

CHAPTER XIX

ORDNANCE SURVEY SIGNS

THE scale of your map will determine what can be included in the map. In the plan of your classroom you can show the position of the desks, in that of



Map 3.—Part of the Ordnance Survey Map of the Isle of Wight.

(Reproduced from the Ordnance Survey by permission of H.M. Stationery Office.)

your school the position of the rooms, and in the map of the main roads leading to your school it may be possible to show the separate buildings. In Map 3, which is drawn to a scale of 1 inch to 1 mile, it is impossible to show the actual buildings, or even all the streets in the towns and villages. If the scale of the map is less than 1 inch to 10 miles it is impossible to show towns, except by dots which mark their position, while rivers are shown by lines varying in thickness according to their width.

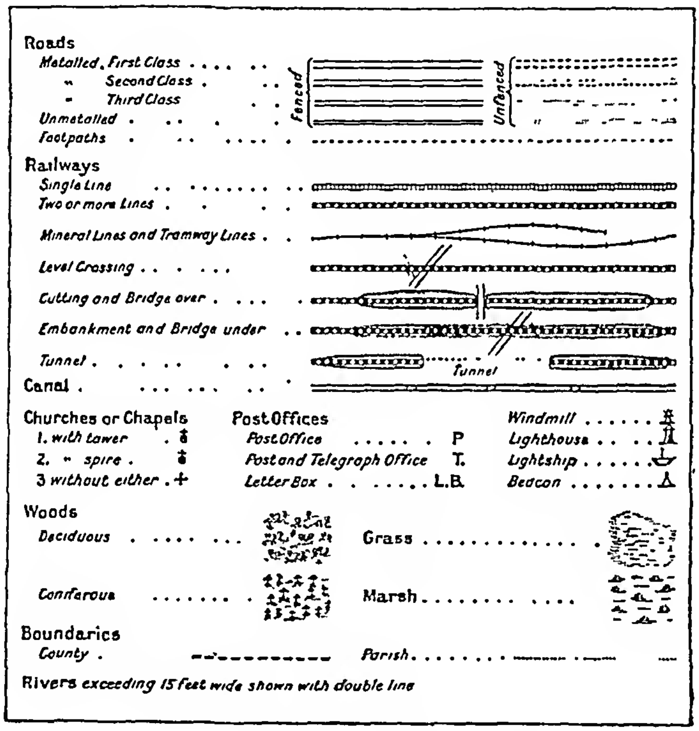


FIG. 33.—ORDNANCE SURVEY SIGNS.

The Governments of most countries publish Survey Maps of all parts of their country. These are drawn to various scales; thus in Britain we have maps drawn to a scale of 6 inches to a mile, 1 inch to a mile, etc. Fig. 33 shows the chief symbols used in these Ordnance Survey Maps. You should learn these, and be able to describe the country shown in Ordnance Maps.

Map 3 is a copy of part of such a map. On it you will notice that the Medina River flows northward from Newport and has its estuary at Cowes; that a single-line railway and a main road, both following the river valley, link these towns to each other. You should also note which parts are wooded, where there are post offices, churches, and so on.

Looking still more closely at this map, it will be seen that the hills and hollows are shown by shading. These lines of shading are known as hachures, but we shall learn more about these and other methods of showing hills and valleys in the next chapter.

Survey Maps of other parts of the world have to introduce different symbols to meet their special needs. Thus in an undeveloped area it is necessary to show rough tracks, rest-houses, the position of water-holes and wells, cultivated regions, and lands granted for mining and other concessions by the Government.

EXERCISES

1. From the Ordnance Survey Map of your own locality find the nearest railway. Where does the road cross it? Is this railway in a cutting or on an embankment? Does the road cross the railway by a bridge over or under it, or by a level-crossing? Is the railway single- or double-lined? Where is the highest land on your map? Where is the river? Which direction does it flow? Describe the country within a three-mile radius of the school.

2. Draw a map showing a double line of railway running from south-west to north-east. In the south part of the map the railway is on an embankment and passes through low grass lands, crossing a stream by means of a bridge. In the centre of the map the railway passes through a wood, on the other side of which it passes under the main road by a bridge. The land here is much higher and the railway is in a deep cutting.

3. Study Map 3 and state what you would see on a journey between Newport and Cowes, following the main road.

Teacher's Note.—Many similar exercises will be suggested by a study of Ordnance Survey Maps of the district, copies of which should be in every school.

CHAPTER XX

CONTOURS

How Relief is Shown

BY the Relief of the Land is meant all those inequalities in its surface which form hills and valleys, tablelands and plains. It would be quite impossible to show these in your atlas by uneven surfaces, and in this chapter we are going to learn how we represent them on a flat map. Turn to one of the "physical" maps in your atlas, and you will see that the lower areas are coloured green, while the higher regions are coloured in gradually darkening shades of brown. The line which separates one colour from another is called a *Contour Line*, and all places on that line are the same height above mean sea-level. The land on one side of the contour is lower, and on the other side is higher than that on the actual contour line.

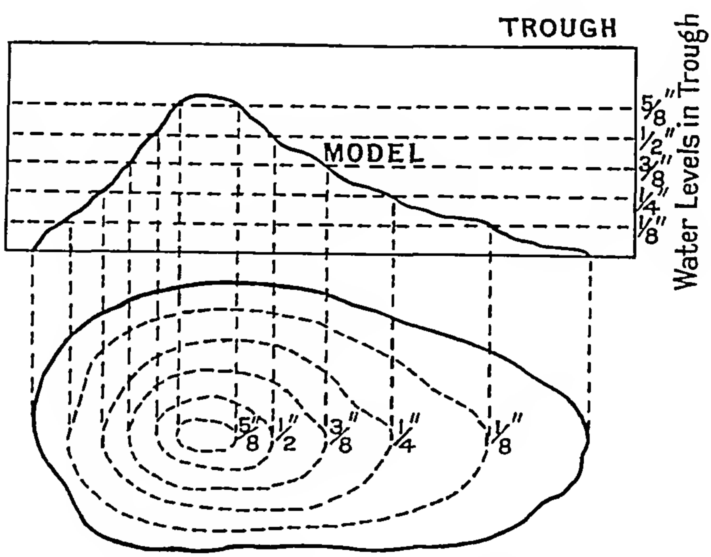


FIG. 34.—CONTOUR MAP OF MOUNTAIN ISLAND.

Your school globe has probably a smooth varnished surface. Some globes are made with the higher parts raised. Let us see which is more nearly correct. Suppose that the axis of your globe is 16 inches in length, which represents 8000 miles, then 1 mile on your globe will be represented by 1/500 of an inch. Mt. Everest, the highest mountain, is between five and six miles high, and should thus be shown by about 1/100 part of an inch, or less than the thickness of a coat of varnish, and all other mountains

FIG. 35.—CONTOUR MAP OF PENINSULA AND PEAKS.

and hills would be very much less. Clearly, then, the mountains shown on the raised school globe have to be very much exaggerated. For similar reasons it would be incorrect to show the mountains raised on a map of Asia. Even on a map of a small country, such as England, the height of the mountains only bears the same relation to the whole area that the head on a penny bears to the remainder.

In order to understand the relationship between contours on the map and actual surface features, obtain a

large glass jar or trough. Paste a narrow vertical strip of paper marked in eighths of an inch outside the vessel. If you make clay models of simple surface features and place them in turn in the glass trough, water can be poured in, so that the water-level forms a contour line on the model.

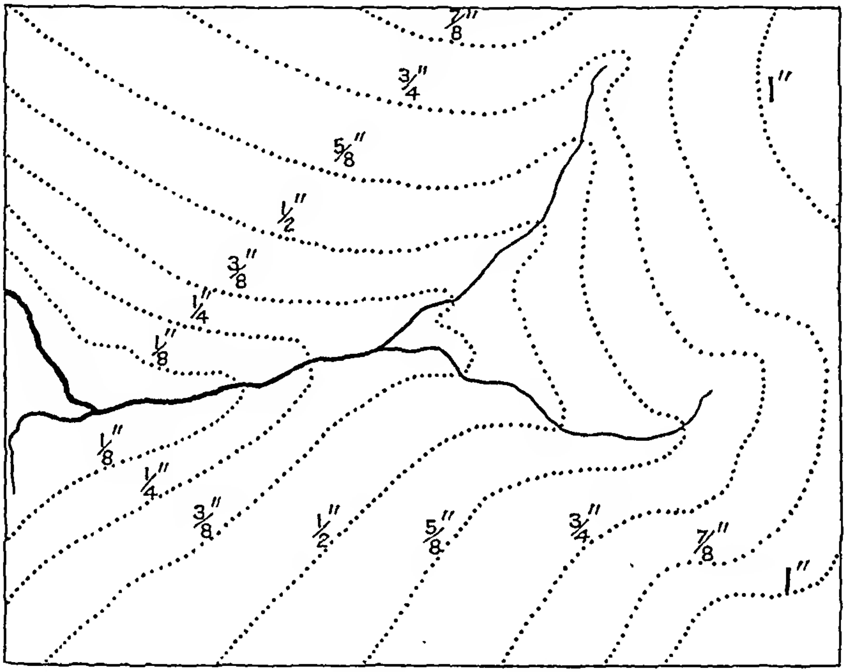


Fig. 36.—Contour Map of River Valley.

Fig. 34 shows a model of a mountain with one steep and one gradual slope. Place such a model in the glass trough, and pour in just sufficient water to cover the bottom of the vessel. Then draw on paper the shape of your model at *water-level*. Pour in some more water to the depth of $\frac{1}{8}$ of an inch, and inside the first outline again draw the shape at water-level. Continue the drawings for depths of $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ inch, etc., until the model is entirely covered. You will then have a diagram similar to Fig. 34, with contour lines for each eighth of an inch.

In the same manner, using a model of a peninsula with two mountain peaks separated by a pass, obtain a contour map like Fig. 35. Repeat the same experiment with a model of a river valley, and you will obtain a contour map similar to Fig. 36.

The student should now turn to Map 1 at the commencement of this book, which shows a simple river valley with swift-flowing tributaries coming from higher land on both north and south. Notice that the contours are closer together in the north than in the south, showing that the slopes are steeper. As a result the streams are swifter and cut steep narrow-sided valleys. Notice that a railway makes use of one of these valleys to cross the hill ridge on the north.

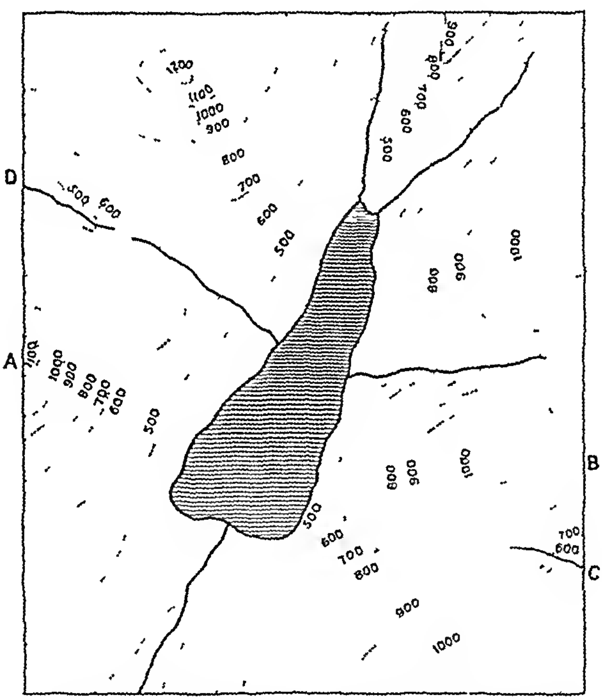


Fig. 37.—Contour Map of Mountain Area.

Fig. 37 shows a lake surrounded by mountainous land. On the north two swift-flowing rivers, cutting deep narrow valleys, flow into the head of the lake, and other streams flow into it from valleys on either side, whilst it is drained to the south by a river with a much wider valley. The student should notice that the slopes on the east are very steep near the lake, while at higher elevations the slopes are much more gradual. Hence the slope to the lake is convex, and, if you were in a boat on the water, you would be unable to see the mountain peaks on the east

side, because the steep lower slopes would block your view. On the other side of the lake the lower slopes are gradual, while higher up they become steeper. This forms a concave slope, and the mountain peaks would be visible from the water. Notice on the west that the source of a transverse stream (*i.e.* one which is at right angles to the main valley), flowing into the lake, is hardly separated from the headwaters of another river, flowing in the opposite direction. Two transverse valleys such as these, connected by a *pass* or *col*, would form a natural route leading from the lake area. On the east a similar transverse valley provides a natural passage between two peaks.

EXERCISES

1. Paint the drawings you made in connection with Figs. 34, 35, and 36, in different shades of brown, using the palest shade possible for the lowest land and adding a little more colour for each of the other levels.
2. Cut out pieces of cardboard the same size and shape as the different contours in Figs. 34, 35, 36, and build up models of each.
3. On Map 3 trace the 100-foot and the 200-foot contour lines and describe the relief of the land. The figures inserted on the map also give heights, and will enable you to follow the fine contour lines.
4. Make a copy of Fig. 38, omitting the sections. Colour it in different shades of brown. Insert the probable course of a longitudinal stream (*i.e.* one flowing parallel with the mountain ridge), two transverse streams, and a col. Show also the probable direction taken by two routes, one running from north to south and one from east to west.
5. Draw a contour map showing a river basin with a main stream flowing south-east, receiving two swift tributaries on the left bank, and a slow one on the right.

CHAPTER XXI

CONTOURS AND SECTIONS

SECTIONS can be obtained from contours, showing what the appearance of the country represented would be if it could be cut through and one of the cut

faces exposed as in the side of a railway cutting. Such sections are used for military purposes in determining the gradients of roads, and for railway purposes in finding the gradients of proposed lines and for tunnelling.

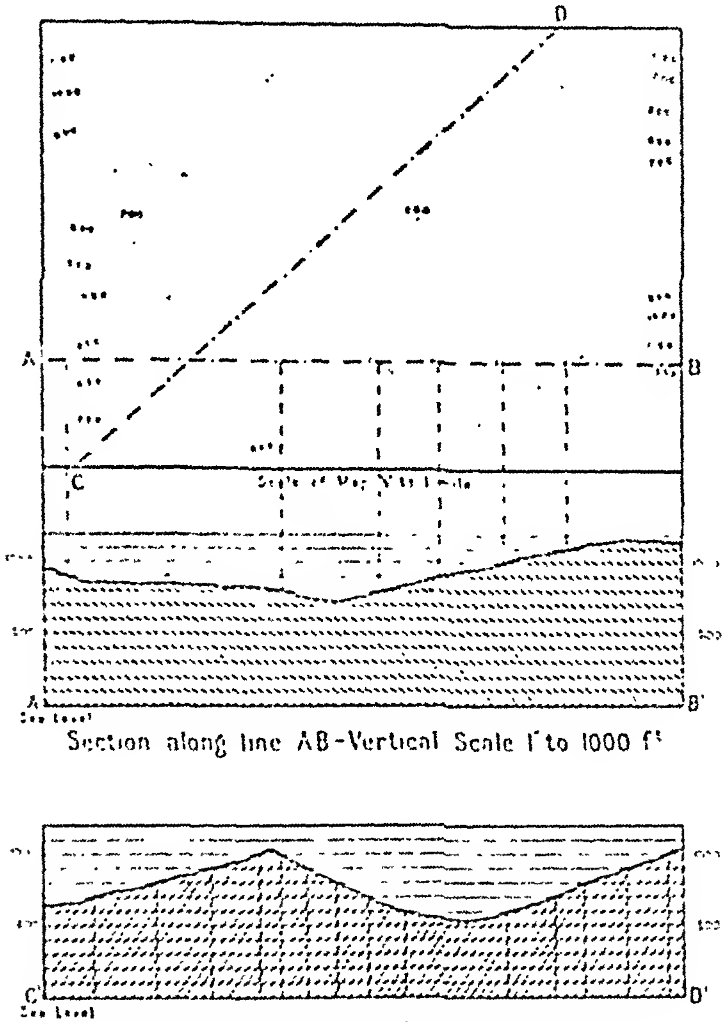


Fig. 38. - Contours and Sections.

The section of this kind that is simplest to draw is a horizontal one, running due east and west across the map. Fig. 38 represents hilly country. The first section is one in an east and west direction through A B. Before draw-

ing the section we must decide on a vertical scale for it. The scale of the map is $\frac{1}{2}$ inch to 1 mile; the greatest height is 1200 feet. If $\frac{1}{2}$ inch stands for 63,360 inches, each part of the map is $\frac{1}{126720}$ of its actual size, which means that the highest point in our section would be represented by $\frac{1}{8}$ inch, if we used the same vertical and horizontal scales. This is impossible, and we therefore must choose a new vertical scale, in this case 1 inch to 1000 feet. From A and B drop vertical lines to a section line A^1 B^1 below. Draw above A^1 B^1 a number of parallel lines $\frac{1}{10}$ inch apart. Letting A^1 B^1 stand for sea-level, then each one of these lines will stand for intervals of 100 feet. Number these accordingly, and, where the contour lines cut A B, drop perpendiculars to the vertical scale below. We shall then have on the vertical scale a number of points which, if connected, will make up the section.

The section through C D runs from south-west to north-east. Using the same scale—1 inch to 1000 feet—as before, draw a line C^1 D^1 equal in length to C D, and on it draw a number of lines parallel to C D, $\frac{1}{10}$ inch apart. Number these according to the hundreds of feet they represent. Carefully measure where each contour line cuts C D, and transfer to C^1 D^1 below. From these erect perpendiculars to the corresponding heights in the vertical scale below, and then join up as before.

In maps of mountainous areas you will find that the intervals between the different contours are sometimes 250 feet, and often 500 feet. In choosing a vertical scale it is advisable not to exaggerate more than is necessary to show the slope of the land. If, for example, you find that the highest point on your section line is 5000 feet, choose a vertical scale of 5000 feet to 1 inch, then intervals of $\frac{1}{10}$ of an inch on your section will represent rises of 500 feet.

EXERCISES

1. Make a cardboard model of Fig. 38 by cutting shapes similar to the contours and fixing them on the top of each other. Cut each separate piece in two parts where the section line C D cuts it. You will then have a representation of the whole model and can expose the cut face along C D. Compare this with the section C^1 D^1 in Fig. 38.
2. On Fig. 37 draw a section from A to B. State which

slopes are convex and which concave. (Note that the surface of the lake is over 400 feet above sea-level.)

3. Describe how you would draw a section, and illustrate your answer by making a section from north to south on Map 1.

4. In Fig. 38 show the probable course taken by a railway joining C to D.

CHAPTER XXII

HOW MAPS ARE MADE

Maps of Small Areas

IT has been shown in an earlier chapter how to take measurements and draw plans of rooms and buildings to scale. You can measure your playing field with the aid of a chain and links and a simple cross-staff as shown in Fig. 39, and then draw a plan to scale. The cross-staff you can make for yourself by taking two strips of wood, each about a foot long, and fixing them at right angles to

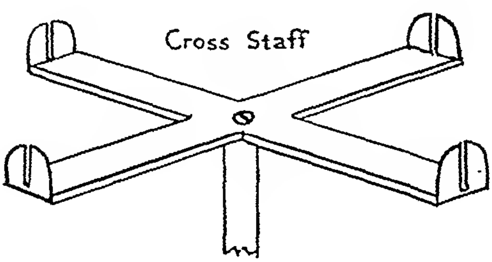


FIG. 39.

a short rod. The four sighters are best made by cutting four semicircular discs in thin metal and making a vertical slit in each.

Plane Table.—Sometimes it is impossible to walk over an area to measure it because of obstacles in the way. In such a case you can use a Plane Table as shown in

Fig. 40. It consists of a drawing-board fixed on a tripod stand. The Sight Rule you can make for yourself.

With such apparatus it is possible to survey an irregular area as in Fig. 40. First choose a base line A B, accurately measure it, and draw it to scale. Fixing the sight rule at A, rotate it, and in turn sight the points B C D E. Now go to B, fix the sight rule, and repeat the operation. Where the lines intersect will give you the necessary points C D E, and, knowing the scale to which A B was drawn, it is possible to find the distance between any two points.

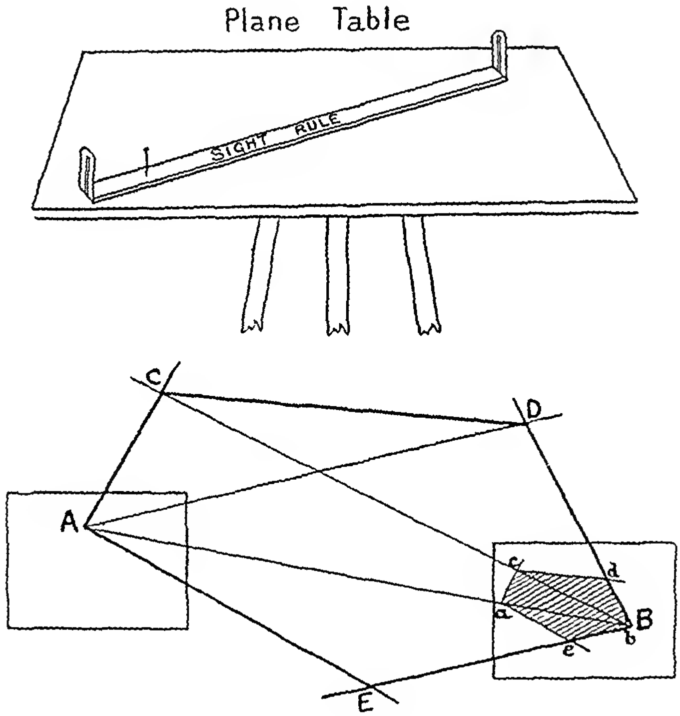


Fig. 40.—Plane-table Surveying.

For very accurate surveys a *Theodolite* is used. This consists of a small telescope capable of moving both in a vertical and a horizontal plane, with attachments for reading the smallest fraction of a degree. With such instruments the Government surveyors have made a complete survey of the British Isles, and from this survey, Ordnance Survey Maps have been drawn to different scales.

Measuring Heights

The simplest instrument for measuring heights is a *Clinometer*. You can make one by taking a thin strip of wood and fixing a sighter at each end. In the centre of this strip fix a semicircular disc marked in degrees as shown in Fig. 41.

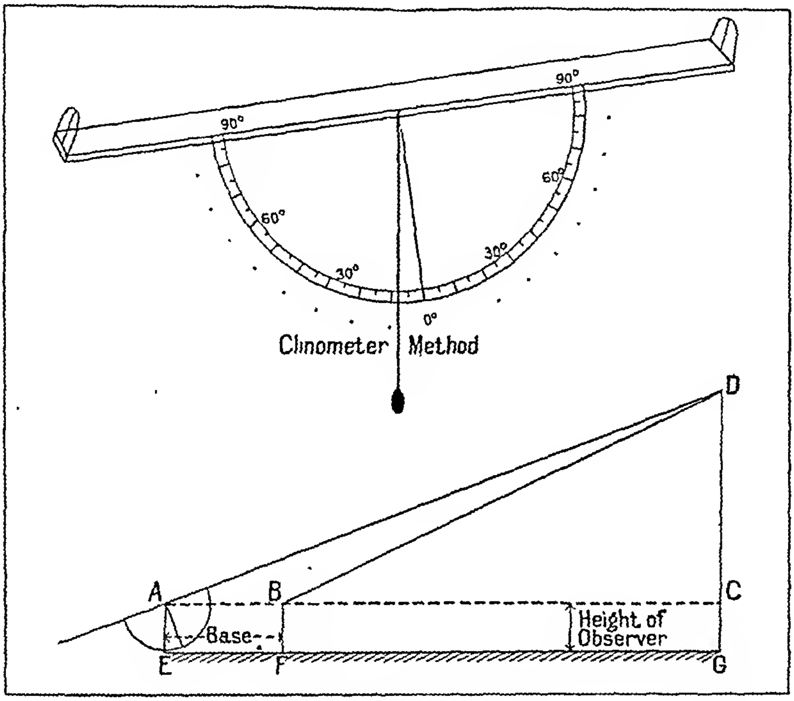


FIG. 41.—CLINOMETER.

To measure by this method you first select two points E and F, from both of which it is possible to see the point D, whose height has to be measured. These two points should be separated by practically level ground. From A, which is vertically above E at a distance of the height of the observer, the clinometer is used to sight the point D, and the angle that the plumb-line is deflected from the 0° of the scale is the angle of elevation at that point. Repeat the same at B, and find the angle of elevation. Knowing the distance of A B by measurement, this can be drawn to scale, and the angles of elevation of D from A and B can be inserted. The intersection of these gives the point

D, and from the scale the distance C D can be obtained, which, added to the height of the observer, will give the height to be obtained.

For accurate measurements of height the Vertical Angle of the Theodolite is used.

Plotting of Contours

Having surveyed a district and drawn a map of it to scale, the surveyor inserts the heights of the land at each

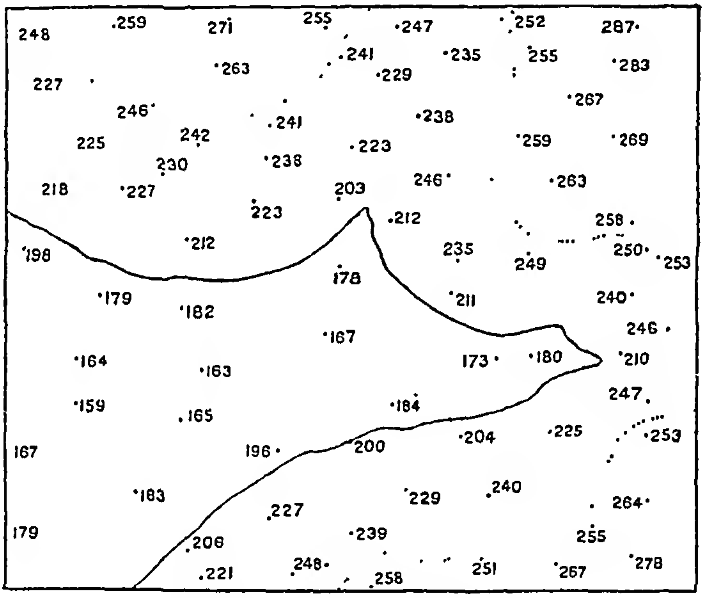


FIG. 42.—PLOTTING CONTOURS.

place where he has measured them, and from these he plots the contour lines. In Fig. 42, if he wishes to draw the 200-feet contour line, he not only connects up all places which are 200 feet above sea-level, but draws his line so that all places above 200 feet are on one side of his line and all places below 200 feet are on the other side. If on one side he has a height of 218 feet, and on the other side a height of 198 feet, he draws his line between the two, but nearer the 198-feet figure because that figure is nearer 200 feet. In a similar manner the 250-feet vertical lines can be drawn.

From deep-sea soundings contours are drawn to represent sea-depths, and these maps of the sea, or Admiralty Charts, are very useful to sailors in determining the course of a ship, especially when it is approaching a port or a river estuary.

Maps of Large Areas

If you think for a moment you will realise that, because the earth is a sphere, all the maps in our atlases should not be on flat surfaces, but should be curved and form parts of a globe. Such a map of the British Isles would only be slightly curved, because it would be taken from a very large globe, but the map of Asia, extending from the Equator through 170 degrees of longitude, would be nearly a quarter of a sphere. It would be quite impossible to carry an atlas of such curved maps about with you, so by Map Projections we try to represent such maps on a flat surface with as little distortion as possible.

Peel from an orange as large a portion of the rind as possible. Notice its shape, and try to fix the rind flat on a board with drawing-pins. You will find that it will split. Take a large india-rubber ball which is worn out, and on it paint the continents. Cut Asia from it, and try to pin it flat on a board. You will notice that it is stretched out of shape.

In **Map Projection** we try to show the shadow of a globe upon sensitised paper. If we take a wire globe, in which the wires represent the parallels of latitude and the meridians of longitude, we can place the correct portions of land between them, if we transfer the shadows of the wires to the paper.

In *Mercator's Projection*, which is used for maps of the world as a whole, we wrap a sheet of such paper in the form of a cylinder round the globe. Where it touches the globe at the Equator the distances are quite correct, but if you compare areas farther away from the Equator as shown on the map with those on the globe, you will

find they are far too large in proportion, because all the parallels on the map are the same length.

Conical Projection is used for maps of parts of the globe. A cone is placed so as to touch the globe between the two extreme points required to be shown on the map. The meridians and parallels are then transferred to the cone. The measurements where the cone touched the globe are quite correct, but the errors both in distance and area increase with distance from it. Therefore maps of small

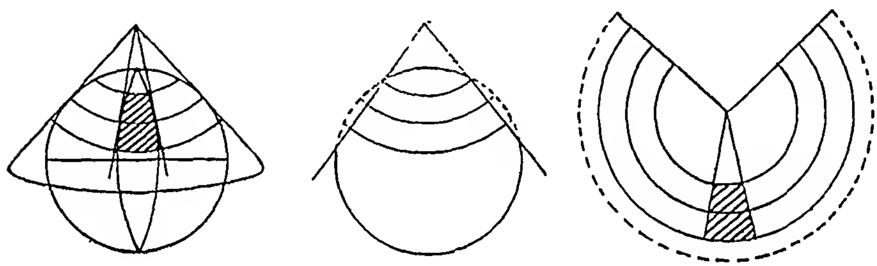


FIG. 43.—CONICAL PROJECTION.

areas are almost correct, but those of continents are incorrect on this Projection.

There are many other methods of projection for obtaining maps of the world as a whole, maps of hemispheres, etc., but a full understanding of the subject involves a knowledge of advanced mathematics, and is too difficult for you to understand at present.

EXERCISES

1. Construct a simple cross-staff, and, with the help of one of your friends, measure your playing-field and draw a plan.
2. With a plane table make a plan of your playing-field.
3. Measure the height of some tall tower or spire in your neighbourhood with a clinometer.
4. From the Ordnance Survey Map of your area transfer the spot heights to a piece of tracing paper and try to plot contour lines.
5. What is Map Projection? What difficulty is it trying to overcome?

SECTION V.—THE CLIMATE OF THE EARTH

CHAPTER XXIII

CLIMATIC CHARTS AND MAPS

Climate and Weather

THE Earth is surrounded by an outer covering of air called the *Atmosphere.* The temperature of this air as it varies from day to day, the direction and force of the moving air or wind, and the amount of the rainfall, all measured over a limited period, we describe as the *Weather.* The *Average of the Weather* for any place over a prolonged period is its *Climate.*

We must not confuse climate and weather. Weather is the atmospheric conditions for a particular period. Thus a person coming to the British Isles in 1921 might say, we had a hot, dry summer with no rain, and another coming in 1931 might equally say we had a cold, wet summer. Both are describing the summer weather for a particular period, and not the climate, which is the average summer conditions, taken over a number of years. The climate described in your geography books is based on the averages of twenty or more years.

Atmospheric Temperature

Daily records of temperature are taken by "maximum and minimum thermometers," which are placed in a box, supported by four thin wooden legs to prevent conduction of heat or cold from the ground. Open slot sides allow a free current of air shaded from the direct rays of the sun.

From the observations of maximum and minimum thermometers it is possible to obtain the daily, monthly, or yearly average, and from these to get the Mean Monthly, or Mean Annual Temperature.

Mean Monthly Temperature is the average temperature for a certain month during a number of years.

Mean Annual Temperature is the average temperature of the whole year taken for a number of years.

By taking daily readings of the thermometer, it is possible to make daily temperature charts; but these are of little use, as they show only the differences in temperature for such a limited period. Fig. 45, which shows

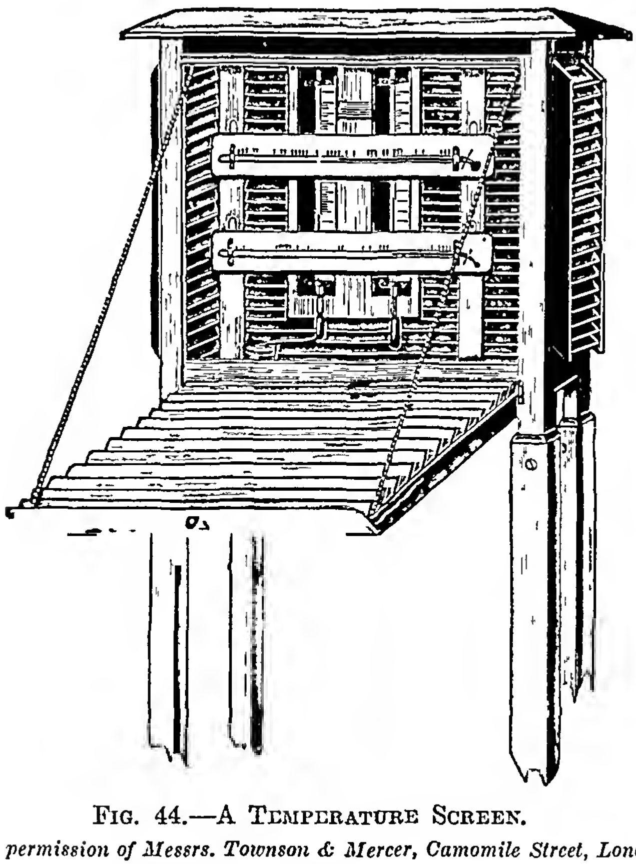


Fig. 44.—A Temperature Screen.
(*By permission of Messrs. Townson & Mercer, Camomile Street, London.*)

Mean Monthly Temperatures, is more valuable, because from it we can obtain the *Range of Temperature*, that is, the difference between the hottest and coldest periods of the year.

Atmospheric Pressure

All movements of the air, or winds, are due to differences in air pressure, because the air endeavours to maintain everywhere the same degree of pressure upon the surface of the earth. This pressure of the air is

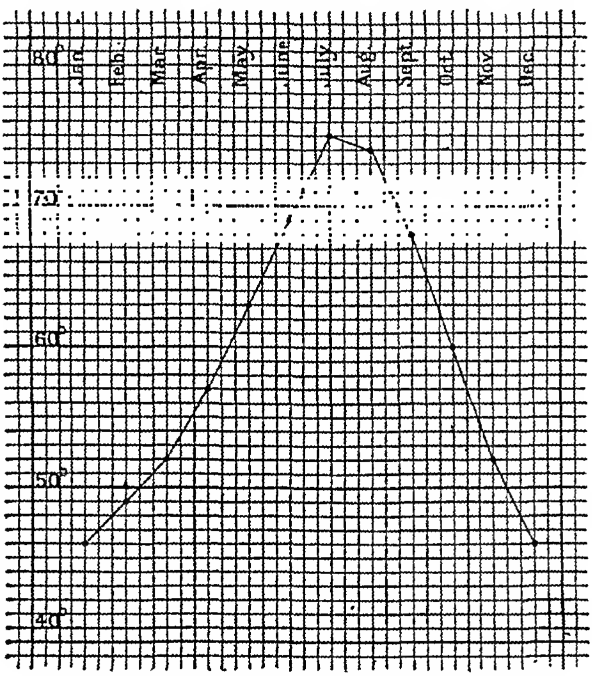


FIG. 45.—MEAN MONTHLY TEMPERATURE CHART.

measured by a barometer. The most convenient form for taking records is a *Self-Recording Barometer or Barograph,* on which a clockwork mechanism unwinds off a cylinder an equal amount of squared paper each day. On this the Barometer automatically records its variations.

From daily observations of pressures it is possible to obtain monthly or yearly averages, and from these to get the *Mean Monthly* or *Mean Annual Pressures.* Records of daily pressure are also useful in constructing weather charts and maps which help to forecast the weather.

Wind Direction

In a later chapter we shall learn that winds are one of the chief causes of climate, and therefore it is important to take into account the direction of the prevailing winds.

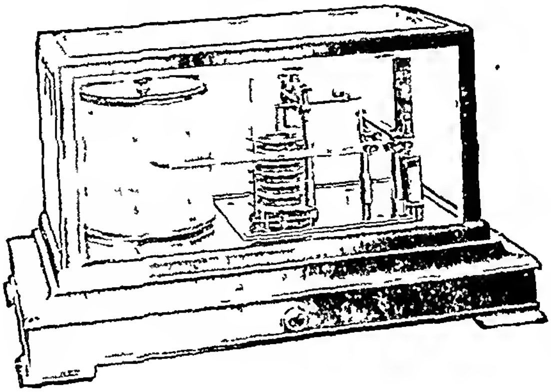


FIG. 46.—A BAROGRAPH.
(By permission of Messrs. Townson & Mercer, Camomile Street, London.)

The direction from which a wind is blowing can be seen by a weather vane. You will doubtless find one on a church tower or public building in your own locality. *Notice carefully that the arrow is pointing to the direction whence the wind is blowing, and that a wind is always named from the direction from which it blows.*

A Wind Rose is an excellent means of keeping a record of the direction of the wind. In Fig. 47 you will notice a number of squares on each of the spokes of the Wind Rose, pointing to the different directions of the compass. Every day we fill in one of these squares according to the direction of the wind. By filling them according to the directions given at the foot of the diagram, we not only have a record of the wind direction, but also the relation between it and the rainfall.

Rainfall

In studying the climate of any place, it is essential to know the amount of rainfall and the times of year at which it occurs. Daily records of rainfall are therefore

taken, and charts and maps are drawn similar to the Charts and Maps of Temperature and Pressure.

The Rain Gauge is an instrument for measuring rainfall. It consists of :

1. An outer galvanised can, A, which is sunk into the ground to the rim BC.

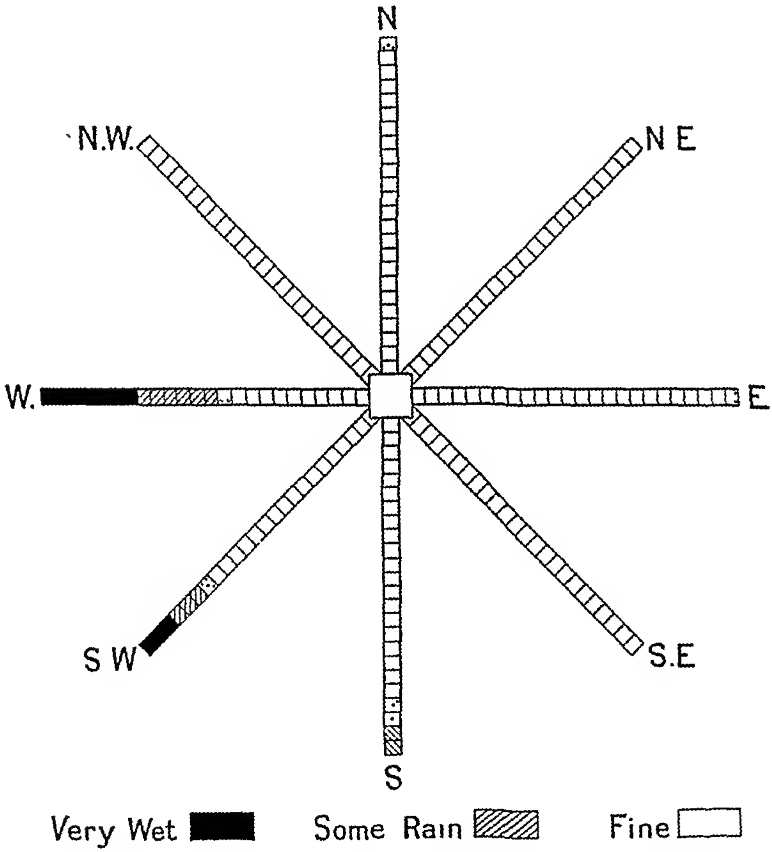


FIG. 47.—A WIND-ROSE RECORDING WINDS AND RAINY DAYS.

2. A funnel BCD which carries the rain falling on the surface area of the can to an inner graduated jar, E. This prevents any subsequent heat evaporating the water in the can.

3. The glass jar, E, is removable. This jar is graduated according to the relation between the surface area of the outer can, A, and the surface area of the glass jar, E.

Suppose the outer can, A, has a surface ten times that of the cylindrical glass jar, then 1 inch of rain falling on the outer can would fill the glass jar to a depth of 10 inches. Hence graduations on the glass jar are marked in proportion to the surface area of the outer can.

By adding together *the total inches of rain which have fallen during the month,* and averaging this total with

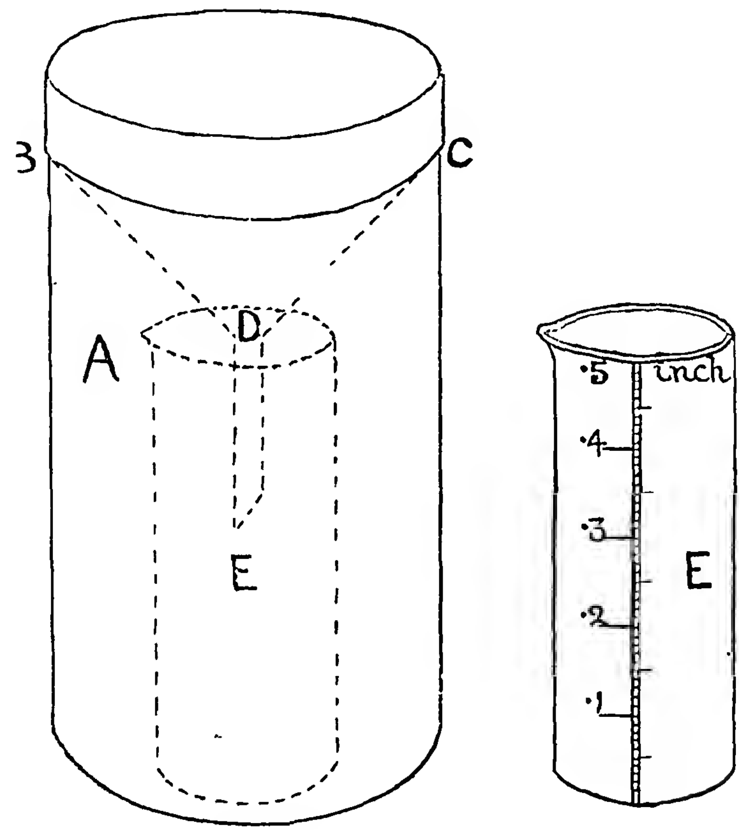


FIG. 48.—RAIN GAUGE.

totals for the same month in preceding years, you obtain the *Mean Monthly Rainfall,* and by taking the *total for the year* and averaging it with the totals for previous years, you get the *Mean Annual Rainfall.*

Climatic Maps

Records of Temperature, Pressure, and Rainfall are taken daily at places all over the world, and central

meteorological or weather offices in each country collect these data, and from them prepare Mean Monthly and Mean Annual Records. If we want to draw a July Temperature Map for any part of the world, we should obtain a number of Mean Monthly July Temperatures for places well distributed over the whole area, and then plot lines of Equal Temperature in a manner similar to that in which we plotted contours. (See Fig. 42.) These lines of *Equal Temperature* are called *Isotherms*. In a similar manner it is possible to draw Pressure and Rainfall Maps. *Lines of Equal Pressure* are known as *Isobars*, and *Lines of Equal Rainfall* as *Isohyets*.

As the stations at which these records are taken are at different heights, a correction is made, both in temperature and pressure records, for height above sea-level. Air decreases in temperature 1° F. for every 300 feet above sea-level. Hence, if a station were 1800 feet above sea-level, 6° F. would be added to the temperature recorded. Similarly, there is a fall of 1 inch in the barometer for every 900 feet of elevation.

In many of the daily newspapers you will see isobaric maps or weather charts constructed from the records of atmospheric pressure of the previous day. From these it is possible to forecast the weather. Notice that the pressure is not labelled in inches but in *Millibars*. The *Bar*, or unit of atmospheric pressure, is the normal height of mercury supported by the pressure of the air at sea-level. Pressures, in these maps, over 1000 millibars are above normal, and those less than 1000 are below normal. You will notice that the wind direction, shown by arrows, is always towards the low pressures.

EXERCISES

1. Take daily records for a month of temperature, pressure, and rainfall, and construct charts for each. From daily records taken by a weather vane construct a wind-rose. What do you learn from a comparison of these records ?

2. Define Mean Monthly Temperature and Mean Monthly Rainfall. Show how records for them are obtained.

3. What is an Isotherm ? Explain clearly how you would draw an Isothermal map.

4. Describe a Rain Gauge. What is the special purpose of the funnel ?

CHAPTER XXIV

ATMOSPHERIC MOISTURE

AIR always contains water-vapour. The quantity of water-vapour the air is capable of holding depends upon the temperature. When the air at its existing temperature cannot hold any more moisture, then it has reached its *Saturation or Dew Point*. Any fall of temperature below this point will cause the water-vapour in the air to condense, and its surplus moisture will be deposited in the form of *rain, hail, snow, fog, mist, dew*, or *hoar frost*.

After a shower of rain it can be observed how the paths sometimes dry up more quickly than they do at other times. The speed at which this evaporation takes place is determined by the capacity of the air for holding moisture. Evaporation is constantly going on from seas, lakes, rivers, etc., and this evaporated water is taken into the pores of the air as invisible water-vapour.

The air contains *dust particles* or *motes*. These form minute surfaces upon which condensed moisture is deposited.

The quantity of dust particles in the air can be seen in a darkened room where the sun finds its way through a small crack or hole. In the beams thus visible millions of dust motes will be seen.

Dew and Hoar Frost.—The earth is a good conductor and a good radiator of heat, and therefore becomes very hot during the day and as quickly cools after the sun has set. Great evaporation will probably take place during the day, and the atmosphere will be nearly saturated with water-vapour. At night, when the ground

cools, *it cools also the air in contact with it*, and lowers the temperature of that air *below its saturation or dew point.* Hence moisture is deposited in the form of dew. If the temperature of the air is lowered at night *below the freezing-point* as well as below the saturation point, then the moisture is deposited as minute crystals of ice known as *hoar frost.*

A clear, calm night is necessary for the precipitation of dew. A cloudy night prevents the earth from radiating its heat, and therefore from lowering the temperature of the air below dew point. On a windy night, the air is constantly moving, and, before its temperature can be reduced and moisture deposited, it has moved on and yielded place to fresh supplies of air.

Fog and Mist.—A fall of temperature in air which contains a large amount of water-vapour may cause condensation upon the dust motes, and these particles, each holding condensed moisture, form *fogs.* Mists differ from fogs in being much moister. Fogs are prevalent where warm currents of air come in contact with colder currents, *e.g.* where the warm air over the Gulf Stream comes in contact with the cold air over the Arctic currents in the neighbourhood of Newfoundland.

Over large towns fogs are thick, because, in addition to the dust motes, large quantities of soot and smoke are present in the atmosphere.

Mists are prevalent in the evenings over sheets of water, *e.g.* lakes and river valleys. They are due to the ground cooling more quickly than the water, with the result that the vapour rising from the water is cooled by the colder air over the ground. In the morning, when the heat of the sun is sufficient to heat the land, the air in contact with it becomes warmed, and the mist disappears.

Clouds and Rain.—Clouds are fogs or mists in the upper atmosphere. Air, containing water-vapour, rises into the colder upper layers of the atmosphere, where the water-vapour is condensed on the dust particles. These

condensed particles join together and fall as raindrops; but much of this rain is not received on the earth, because, as a rule in its downward passage, it meets unsaturated air, which is able to absorb and hold the water-vapour.

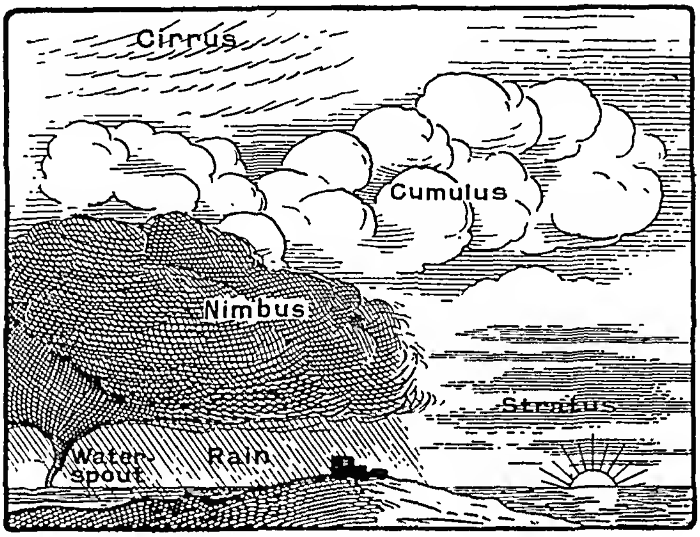


FIG. 49.—CLOUDS.

The chief kinds of clouds are *Cirrus*, *Cumulus*, *Nimbus*, and *Stratus*.

Cirrus Clouds, or "Mares' Tails," are the highest in the sky, and seldom produce rain on the earth. Their average height is from 5 to 7 miles.

Cumulus Clouds, having the appearance of piled-up cotton-wool, are from 2 to 3 miles high. In summer, when the air is capable of taking up more moisture, they seldom produce rain, but they occasionally do so in winter.

Nimbus Clouds are black and generally very low. Hence they are more liable to produce rain.

Stratus Clouds, consisting of horizontal layers, are usually seen on the horizon at sunrise or sunset.

Snow.—If the temperature in the upper atmosphere is below 32° F., then the moisture it contains becomes frozen in the form of six-sided crystals. Many of these crystals join together to form flakes.

Probably many of the clouds in the upper atmosphere are made of snow crystals, but these do not reach the

earth because of the warm temperature at lower levels of the atmosphere. Snow falls only when the temperature of the air in contact with the surface of the earth sinks nearly to freezing-point.

The *snow-line* is that limit above which the heat of the sun is not sufficient to melt all the snow that falls. The height of the snow-line varies in different regions, and frequently varies on opposite sides of the same mountain chain. In tropical Africa it is 16,000 feet above sea-level, in the Alps 9000 feet, and in Spitsbergen at sea-level.

Hailstones are solid pieces of ice, usually small and rounded, and are probably caused by the freezing of raindrops during their passage through cold layers of air.

EXERCISES

1. Define Saturation Point, and explain how air can become capable of holding additional moisture.
2. Explain why: (*a*) Fogs are most prevalent in England during autumn; (*b*) Dew is common in Egypt; (*c*) Morning mists disappear as the sun rises in the heavens; (*d*) Country roads are dusty in summer and muddy in winter.
3. Why is the snow-line higher in the Andes than in the Alps, and why is it higher on the south slopes of the Alps than on the north?

CHAPTER XXV

CAUSES OF CLIMATE

The Slope of the Sun's Rays

IN Chapter VII it was shown that a vertical beam of the sun's rays, because it has less surface to heat, does its heating more effectively than an oblique beam, which has to distribute an equal amount of heat over a greater area. If climate depended solely upon the slope of the sun's rays, then all places receiving the sun's rays

at the same degree of slope would have the same temperature, that is, all parallels of latitude would be isotherms.

Because of the increasing inclination of the sun's rays, there is a decrease in temperature over the earth's surface with distance from the Equator. The range of temperature is also least at the Equator and increases with distance from it. The small range of temperature at the Equator is due to the fact that the rays from the sun received there are vertical or nearly vertical all the year round, but the difference in degree of slope of the sun's rays in summer as compared with winter increases with distance from the Equator. Also the length of the day at the Equator is always twelve hours, but the difference in the length of daylight between summer and winter increases with distance from it.

Calcutta, only 23° north of the Equator, receives nearly vertical rays, while Archangel, 65° north, receives sloping rays. If, from the following figures, you draw two graphs, you will notice (1) the difference in the temperatures, and (2) the difference in the range of temperatures.

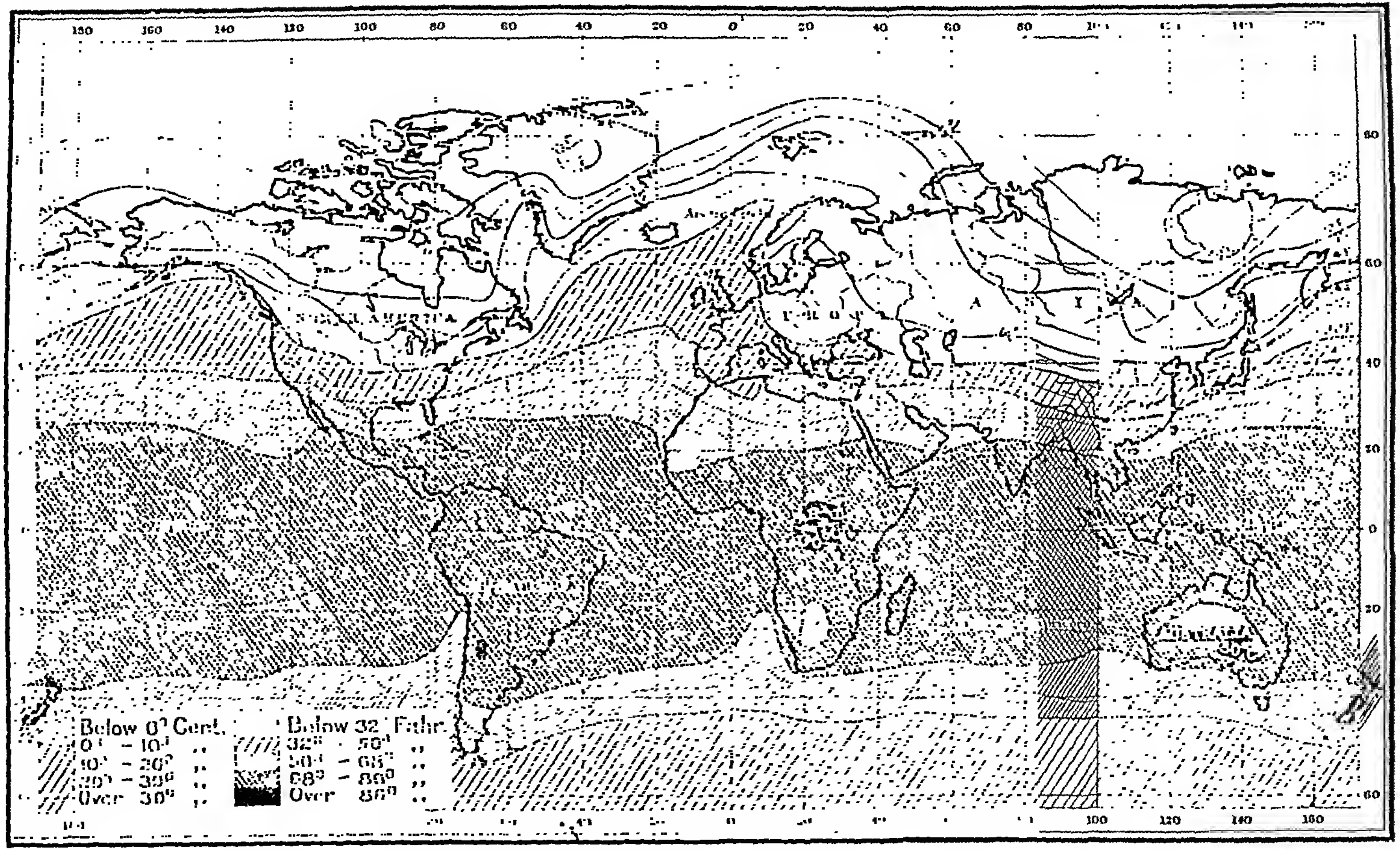
	Jan.	*Feb.*	*Mar.*	*Apr.*	*May.*	*June.*
Calcutta	65° F.	70° F.	79° F.	85° F.	85° F.	84° F.
	July.	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
	83° F.	82° F.	82° F.	80° F.	72° F.	65° F.

	Jan.	*Feb.*	*Mar.*	*Apr.*	*May.*	*June.*
Archangel	7° F.	8° F.	17° F.	27° F.	40° F.	54° F.
	July.	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
	60° F.	56° F.	46° F.	34° F.	20° F.	9° F.

Influence of the Sea

Places which feel the influence of the sea have a more equable climate than places which are far removed from it. The sea does not absorb heat so quickly as the land, and hence in summer it exerts a cooling effect; in winter the sea does not lose its heat so quickly as the land, and therefore at this season has a warming influence.

It must be noted that what happens is not that the sea itself warms the land in winter, but that warmer air from over the sea is carried inland. Hence the equalising influence of the sea is only felt when winds blow across it



Map 4.—Temperature Map of the World—January.

towards the land ; and desert coasts, with great extremes of climate, are found where the prevailing winds blow from the land towards the sea.

An *Insular Climate* is one made equable by the sea. A *Continental Climate* is one of extremes, caused by the absence of the sea's influence.

The following figures are the Mean Monthly Temperatures of Valencia (south-west Ireland), having an equable climate, and Bucharest (Rumania), having a continental type of climate. Draw two graphs to illustrate the variations in temperature, and note that the range of temperature at Bucharest is 45° F. but at Valencia is only 14° F.

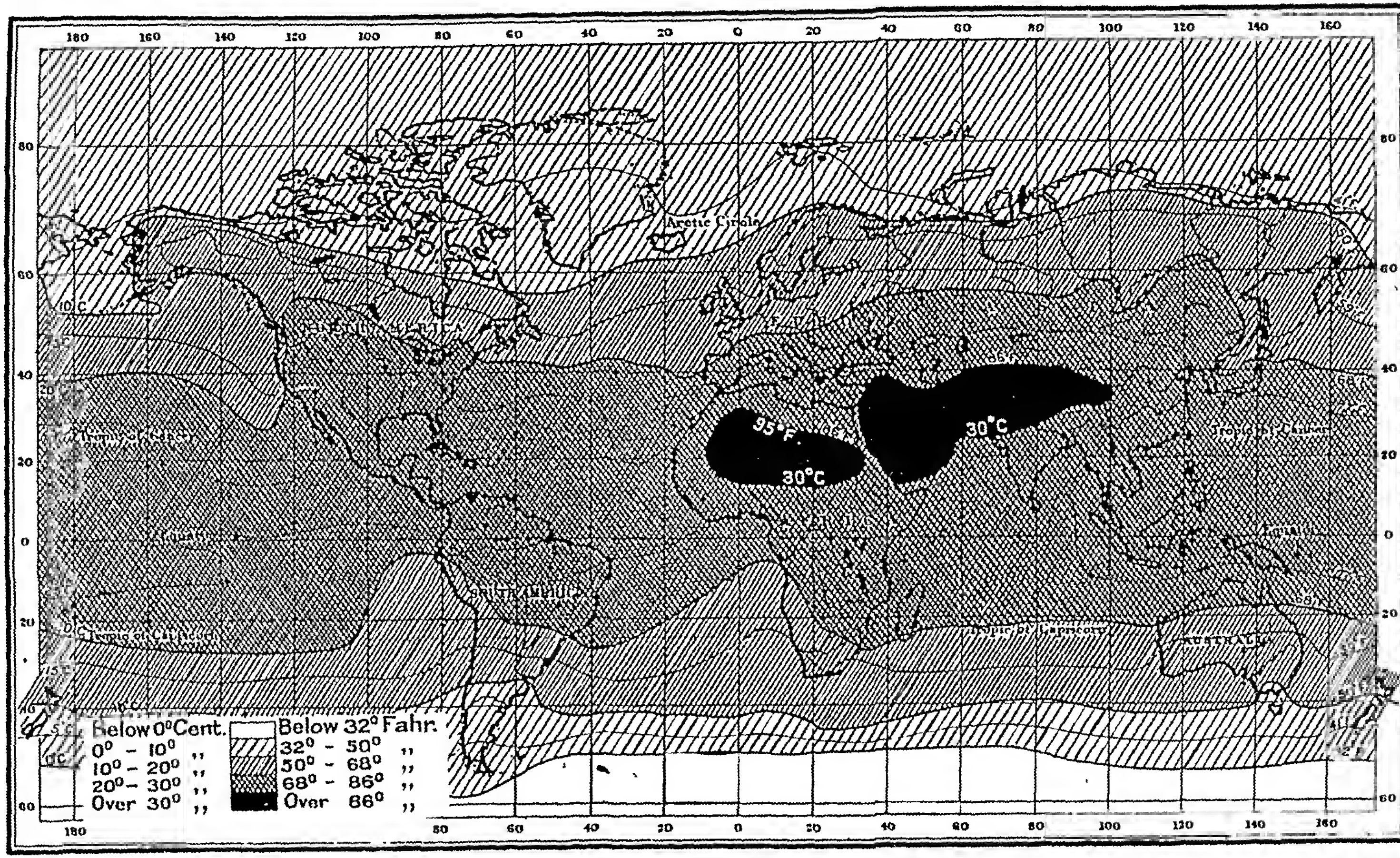
	Jan.	*Feb.*	*Mar.*	*Apr.*	*May.*	*June.*
Valencia	45° F.	45° F.	46° F.	49° F.	52° F.	56° F.
	July.	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
	58° F.	59° F.	56° F.	52° F.	47° F.	45° F.

	Jan.	*Feb.*	*Mar.*	*Apr.*	*May.*	*June.*
Bucharest	26 °F.	28° F.	39° F.	52° F.	61° F.	69° F.
	July.	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
	73° F.	71° F.	63° F.	52° F.	41° F.	31° F.

Elevation

It was shown in Chapter XXIII that an increase in height means a decrease in temperature. This is due to the manner in which the air is heated. The sun's rays pass through the air without producing much effect on it. The earth receives their heat, and radiates it, so that it is absorbed by the water-vapour and the dust motes in the belt of air lying near the surface of the earth. The rarer, or thinner, layers of the upper atmosphere contain less water vapour and fewer dust particles, are thus able to absorb less heat, and consequently are cooler than the lower layers of the atmosphere.

Direction of Mountain Chains.—Mountain ridges which run at right angles to the prevailing winds have a wet windward slope and a dry leeward slope. In order to rise over a mountain barrier an air current ascends—expands because of decrease in atmospheric pressure—cools



MAP 5.—TEMPERATURE MAP OF THE WORLD—JULY.

because of expansion and, because of cooling, can carry less water-vapour—and the condensation of surplus water-vapour causes rainfall on the windward slope. On the lee slope the air current descends, is compressed and heated as pressure increases, and becomes capable of absorbing more and more moisture—thus becoming a drying wind and causing a warmer climate. These dry, warm areas on the lee side of mountains are often known as *Rain-Shadow Areas.*

Climatic Barriers.—Mountains often prevent climatic influences which prevail on one side of a range from reaching and influencing the other side, and in such cases form boundaries between climatic regions. The Himalayas form such a barrier between the monsoon conditions of India and the desert conditions of Central Asia.

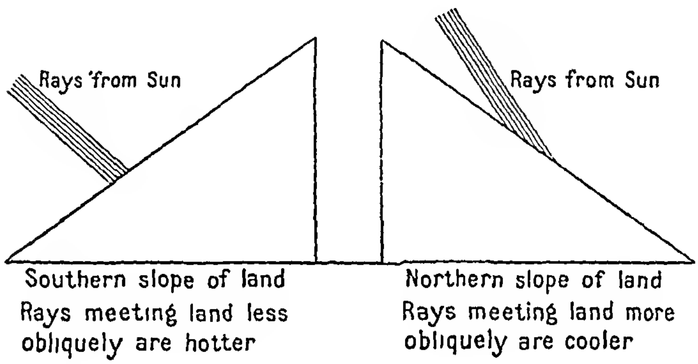


FIG. 50.—EFFECT OF SLOPE OF GROUND.

Slope of the Mountains.—Fig. 50 shows how the amount of heat received from the sun's rays is affected by the direction in which a land-slope faces. Because they face towards the rays of the sun, the southern slopes of the South Downs are warm, while the great Plain of Northern Asia, draining towards the Arctic Ocean, is rendered colder than its position in latitude warrants, because it slopes away from the sun's rays.

EXERCISES

1. Why is it warmer in winter and cooler in summer over the Irish Sea than over the lands bordering it ?

2. Why is it warmer in the Torrid Zone than in the British Isles ?

3. Why are very lofty mountains in hot countries capped with snow all the year through ?

4. Which parts of the British Isles get most rain? Give reasons.

5. What differences would you expect to find between the climates of Moscow (in the centre of Russia) and Edinburgh?

CHAPTER XXVI

REGULAR WINDS

WINDS are one of the chief causes of climate, so, in order to understand the varying climates found in different parts of the world, we must know something of the causes which create differences of atmospheric pressure, and thus set up winds to equalise these differences. We should first remember the following properties of air:

(1) It is *elastic*, and will expand to occupy a larger space or will compress to fill a smaller one.
(2) It *expands when heated*, causing a decrease in pressure, and contracts when cooled, causing an increase in pressure.
(3) The greater the altitude, the less dense becomes the air, because the lower layers of the atmosphere are compressed by the layers above them.
(4) *Air is heavier than water-vapour*, therefore air which contains a large amount of water-vapour will rise above air which contains less.

The wind systems of the world can be divided into three groups: *Regular Winds* which blow continously, *e.g.* Trade Winds; *Periodic Winds* which blow at certain seasons, *e.g.* Monsoons; and *Variable Winds* which blow

at irregular intervals, *e.g.* Cyclones. We will take these winds in turn, and apply the properties of the air, which we have just learned, to ascertain their cause.

Regular Winds

The great heat in the region of the Equator causes the air in contact with the earth to expand and rise. This creates a low atmospheric pressure at the earth's surface, known as the *Equatorial Belt of Calms*, or the *Doldrums*. But such ascending air, known as Convection Currents, causes an increased pressure in the upper atmosphere. There will, therefore, be a movement of air currents, or winds, towards the low pressure belt at the Equator

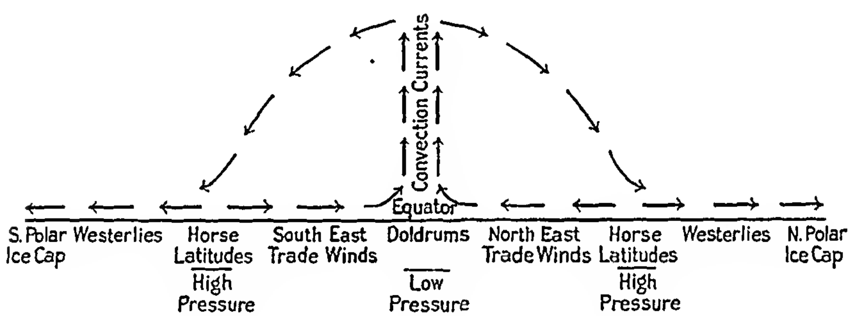


FIG. 51.—FORMATION OF WIND BELTS.

in the lower atmosphere, and from the Equator towards the Poles in the upper atmosphere (see Fig. 51).

The rotation of the earth (and with it, of the atmosphere) round the Poles tends to whirl away air from the Poles, as water whirls away from the centre of a basin which is rotated. Areas of low pressure are therefore created about the latitudes of the Polar Circles. Between these low pressure areas and that at the Equator, two high pressure belts, known as the Calms of Cancer and Capricorn, or, more commonly, as the Horse Latitudes result from the piling up of air, between latitudes 20° and 40° north and south, by the two processes of surface air moving equatorwards and upper air moving polewards. As air always tends to move from a high

pressure area to one of low pressure, winds blow from these high pressure belts towards the Equator (Trade Winds), and blow also towards the Poles (Westerly Winds).

Air which, becoming heated in the equatorial regions, rises into the upper atmosphere, flows off in the upper layers in the direction opposite to that of the Trades. Reaching the temperate regions, it becomes much cooler and denser, and therefore sinks to the lower layers of the atmosphere, and flows towards the Poles.

The Equatorial Belt of Calms, or the Doldrums, is a belt of low pressure into which the Trade Winds blow. When it reaches this belt the air becomes heated, expands, and rises into the colder upper layers. This causes condensation, and consequent heavy rainfall almost every day.

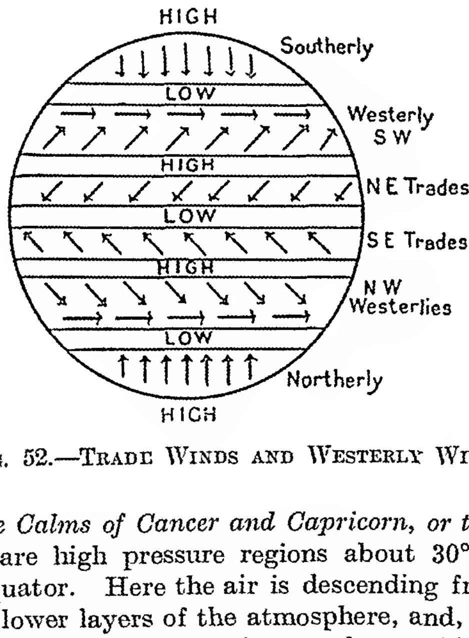


FIG. 52.—TRADE WINDS AND WESTERLY WINDS.

The Calms of Cancer and Capricorn, or the Horse Latitudes, are high pressure regions about 30° N. and S. of the Equator. Here the air is descending from the upper to the lower layers of the atmosphere, and, being warmed in its descent, and therefore made capable of absorbing more moisture, dry weather conditions result.

Direction of the Trade Winds and Westerlies.—As the earth rotates once in twenty-four hours, any point on the Equator has to move faster than places nearer the Poles. The atmosphere moves with the earth, and therefore does so more quickly at the Equator than at the Poles. Thus air which is in process of transfer from the temperate regions to the equator is moving more slowly than air at

the Equator, and lags behind. Consequently the Trade-Currents wind, instead of moving due north and south to the Equator, actually blow from the *north-east* north of the Equator, and from the *south-east* south of the Equator. Similarly, air moving from the high pressure belt at the temperate regions towards the Poles is moving faster than the air at the Poles and gets in front of it. Hence the Westerly Winds appear as winds blowing from the *south-west* and *north-west* north and south of the Equator respectively (see Fig. 52).

Contrasts between Trade and Westerly Winds :

1. Trade Winds blow towards a low pressure centre at the Equator.	1. Westerly winds blow towards low pressure centres near the Poles.
2. Trade Winds, blowing from a cooler to a warmer region, are cooling winds. As they blow to warmer regions, the air gets heated, saturation point is raised, and therefore the air is capable of taking up more moisture. Hence Trade Winds are *dry-weather-producing* winds.	2. Westerly winds, blowing from warmer to cooler regions, are warming winds. As they enter cooler latitudes, their saturation point is lowered, and therefore the air deposits moisture. Hence they are *wet* winds.
3. In the Trade Wind Areas winds are regular and constant and the weather is monotonous.	3. Westerly Wind Areas are subject to cyclonic disturbances and variable weather.

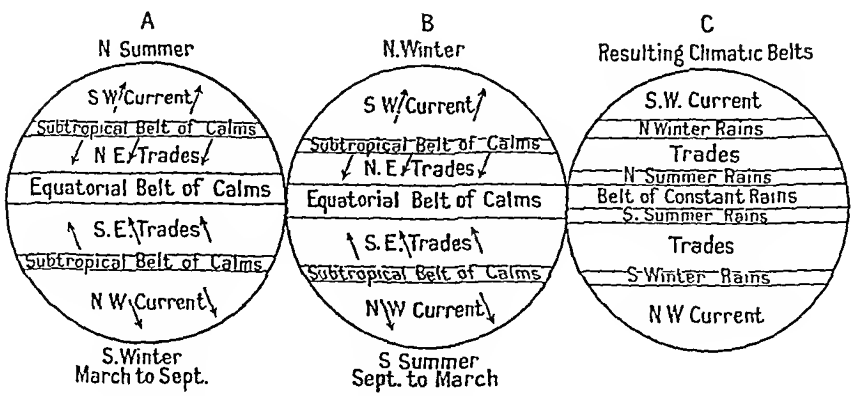


FIG. 53.—MIGRATIONS OF THE THERMAL EQUATOR.

Migration of the Thermal Equator

The Thermal Equator is the line of greatest heat. Owing to the sun shining vertically north of the geographical equator in northern summer, and south of it in northern winter, the Thermal Equator migrates, or moves, north and south with the seasons. This causes the Equatorial Belts of Calms and the Trade Wind Belts to move also, and as a result we have the climatic belts shown in C of Fig. 53.

(1) *Equatorial Belt of Constant Rains.* This falls within the Equatorial Belt of Calms all the year.

(2) *A Belt of Summer Rains* on either side of the Equatorial Belt, which have equatorial rains in summer, but are invaded by the dry Trade Wind Belts in winter.

(3) *Constant Trade Wind Belts.* These are the regions which, despite the migration of the Thermal Equator and with it, of the Trade Winds, never come under any other influence than that of the Trade Winds.

(4) *Winter Rain Belts.* These, through the migration of the Thermal Equator, fall within the dry Trade Wind Belt in summer and are invaded by the wet westerlies in winter.

(5) *Westerly Wind Belts.* These are found roughly north and south of the 40th parallels of Latitude respectively. They fall within the influence of the Westerly Winds all the year.

Roaring Forties.—The Westerly Wind Region south of latitude 40° S. is nearly all occupied by sea, and consequently the winds are not deflected by land masses. They gather great force, and are known as the Roaring Forties. Many vessels, including sailing and cargo boats, proceed to Australia *via* Cape Town, in order to profit by

the assistance of these winds. The return journey is made *via* Cape Horn, so that they again receive the help of the Westerlies. Find this route on your map.

If the surface of the world was everywhere of the same elevation, and if it was either all sea or all land, then the limits of each of the above climatic belts could be defined by certain parallels of latitude. In the succeeding chapter we shall learn how the effects of land and sea distribution and of land elevation cause these belts to vary in size and position, and how periodic winds are set up.

EXERCISES

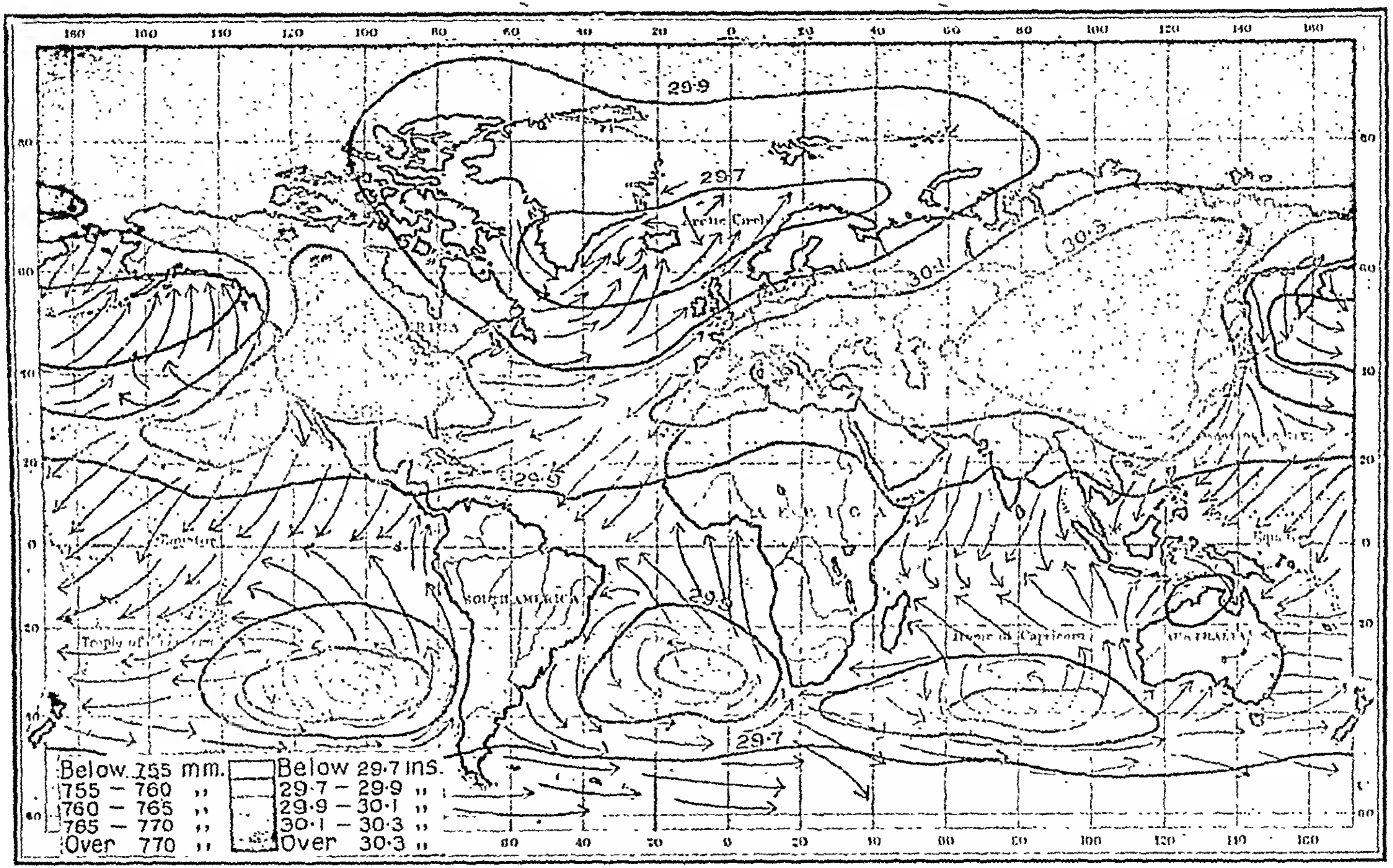
1. Account for the migration of the Thermal Equator, and show the effect of this migration on the climatic belts.
2. Describe carefully the cause of the direction of Trade Winds.
3. Explain why a sailing vessel in travelling from England to Melbourne and home again, goes *via* the Cape of Good Hope and returns *via* Cape Horn.
4. Explain why South Island, New Zealand, is forested on its western slopes and has dry grassy plains on the east.
5. Why does the greatest amount of rain fall at the Equator? How far is it true that rainfall decreases with distance from the Equator ?
6. In what climatic belt are most of the great deserts of the world situated ? From this deduce the cause of their barren condition.

CHAPTER XXVII

PERIODIC AND VARIABLE WINDS

Monsoons

WE learned in the last chapter that on either side of the Equator there is a belt of high pressure between latitudes 20° and 40° north and south. If you look at



MAP 6.—PRESSURE MAP OF THE WORLD—JANUARY.

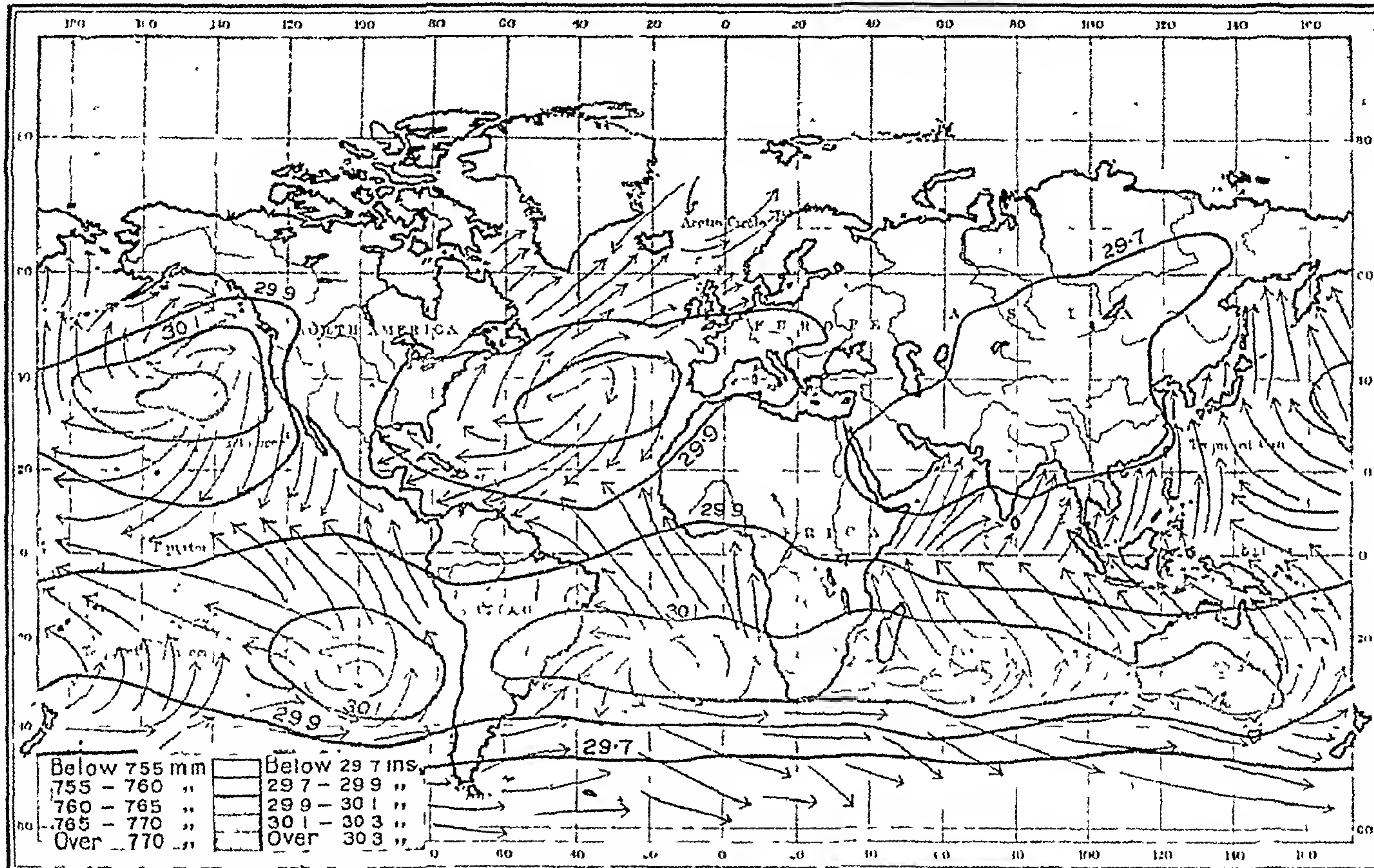
Map 7 you will see that these High Pressure Belts are not both continuous. You will notice that north of the Equator there are high pressures over the sea but low pressures over the land. If you compare Map 7 with Map 6, you will observe that in January the highest pressures north of the Equator are over the land, and that the pressures over the sea are much lower. Notice, also, that the greatest difference between the summer and winter pressures is over the huge land mass of Asia.

South of the Equator you will find similar, though less marked, contrasts, and they are naturally reversed, because in this case January is the summer month.

These great differences are due to the unequal heating of land and water. Land absorbs heat much more quickly than water. It also gives out, or radiates, its heat much more quickly. These great changes in temperature cause the air over a land mass to show high temperature and therefore low pressure in summer, and low temperature and consequently high pressure in winter. This sets up Periodic Winds known as Monsoons.

Towards mid-summer, when a great land mass is very hot, a low atmospheric pressure is set up, due to the ascending air, and an inflow of air takes place from the higher atmospheric pressures over the sea. This inflowing air, charged with water-vapour evaporated from the ocean, causes a wet season for about four months. At the close of summer the land quickly cools, the pressure of the air in contact with it becomes denser, and in late winter there takes place an outflow of air from over the land mass towards the lower pressures over the sea. This causes a dry season over the land, with cooler outward-blowing winds. Between the wet and dry seasons there is an intervening period of two months, during which the land is cooling, and a similar period after the dry season, during which the land is absorbing heat.

You will notice in Maps 6 and 7 that the arrows showing the direction of the winds do not blow into the low pressure systems radially, but spirally—anti-clockwise in



MAP 7.—PRESSURE MAP OF THE WORLD—JULY.

the Northern Hemisphere, and clockwise in the Southern Hemisphere. Fig. 54 shows a high pressure centre and a low pressure centre of the Northern Hemisphere side by side. Notice the isobars and the arrows showing the wind direction. If you stand on any arrow facing the direction in which the arrow is pointing, and thus with your back to the wind, the low pressure will always be on your left in the Northern Hemisphere and on your right in the Southern Hemisphere. This is known as *Buys-Ballot's Law.* In a later chapter we shall show that the ocean currents follow the same law in their direction.

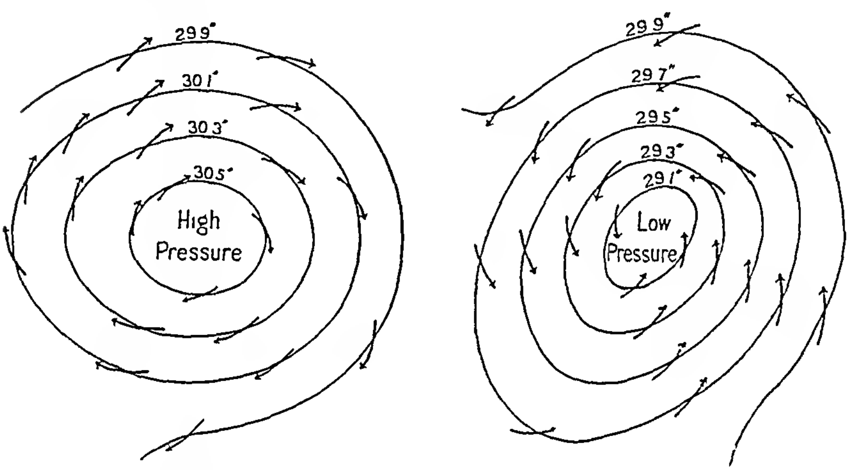


FIG. 54.—SPIRAL MOTION OF WINDS IN NORTHERN HEMISPHERE.

India, Indo-China, Southern China, and Northern Australia are the chief monsoon areas, but similar monsoon effects are felt in other parts of the world wherever there are great land masses bordered by ocean.

Cyclones and Anticyclones

These are Variable Winds. They do not blow regularly at certain seasons of the year, but may occur at any time and may last but a few days. If you study the daily weather charts issued by the Meteorological Office, which are often reproduced in daily newspapers, you will find there low and high pressure systems, similar to those we have been considering, but less in area. They are most commonly found in latitudes 35° to 60°, and differ from the low pressure systems of Monsoons in not being due to differences in temperature. Also they are not

stationary but are in motion, cyclones always following a west to east direction. The causes which set up these pressure systems are difficult to understand, but we can

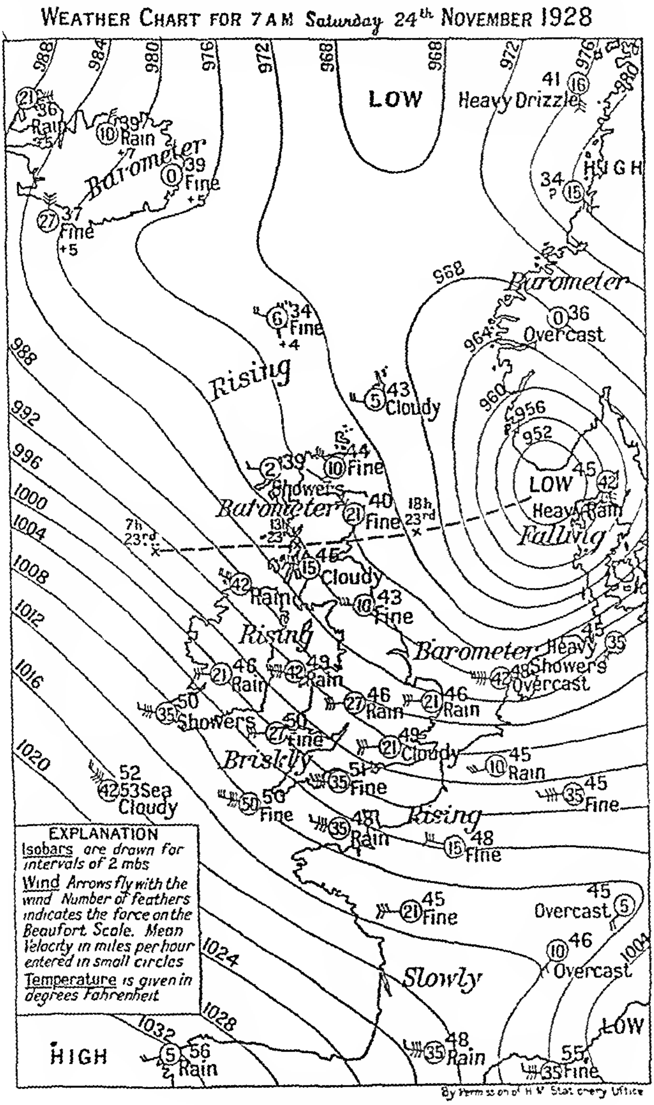


FIG. 55.—CYCLONE.

study their effects and see how they enable us to forecast the weather.

Fig. 55 shows a diagram of a low pressure system. The winds blow spirally inwards towards the centre, and,

in the Northern Hemisphere, in an anti-clockwise direction (Fig. 54). Notice that to the east and south-east the isobars are closer together than they are on the north-

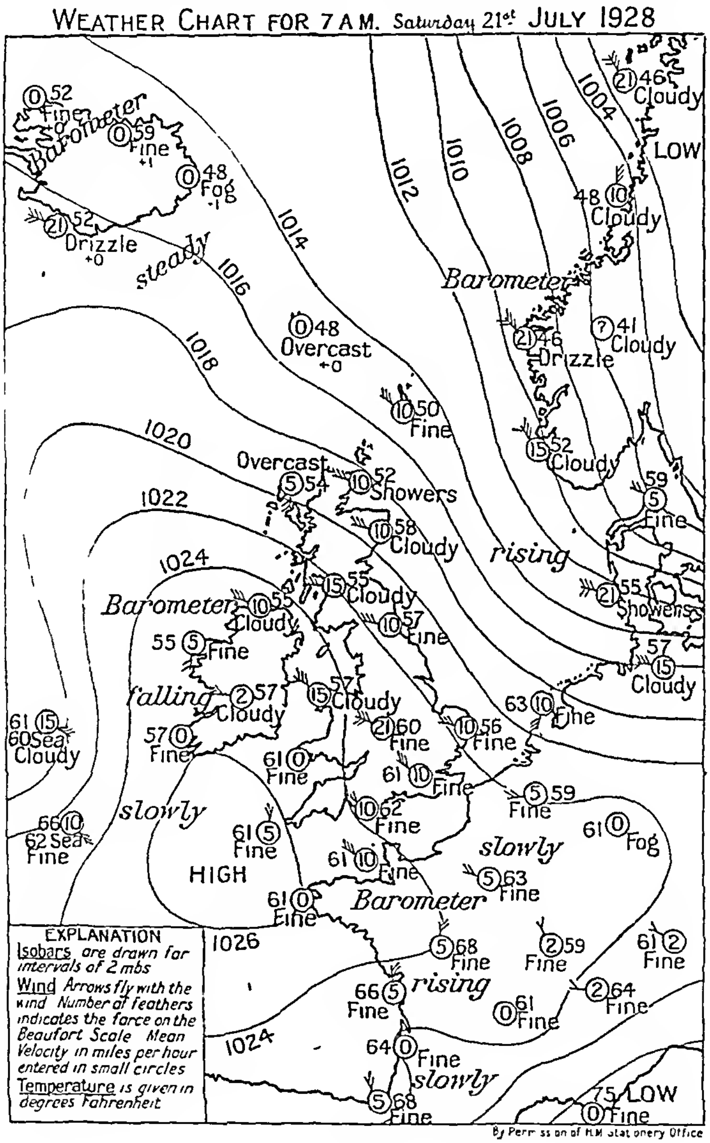


FIG. 56.—ANTICYCLONE.

west. In the south-east, therefore, the winds will be strong and may reach gale force, because the air has to equalise pressure in a small space. When the isobars are close together, we call it a *Steep Barometric Gradient.*

On the north-west the Barometric Gradient is gradual and the winds will be light The area near and in front of the centre of a cyclone experiences cloudy weather and rain.

Such cyclones are constantly passing over the British Isles. If we know the rate at which the whole low pressure system is travelling, and its probable direction, we can forecast the weather. Supposing a cyclone, as in Fig. 55, were travelling across the British Isles towards Central Europe. Then its approach would be heralded by strong winds, dull weather and some showers. Later, the wind would drop, and there would be rain. The retreat of the cyclone would be marked by gentle breezes veering to the north and west, with finer weather conditions. Its passage might take one, two, or three days, according to the rate at which the whole system was travelling.

Fig. 56 shows an anticyclone, which is the reverse of a cyclone. The centre is a region of high pressure, and the winds blow spirally outward in the same direction as the hands move on a clock. Notice that the isobars are rather far apart, and that therefore there is a gradual Barometric Gradient, with light winds. The area covered by the centre of an anticyclone usually experiences fine weather.

Chief Features and Points of Contrast

Cyclone	*Anticyclone*
1. Low Pressure Centre with winds blowing spirally inward.	1. High Pressure Centre with winds blowing spirally outwards.
2. Winds blow in an anti-clockwise direction in the Northern Hemisphere and *vice versa* in the Southern.	2. Winds blow in clockwise direction in Northern Hemisphere and *vice versa* in Southern Hemisphere.
3. Brings windy and wet weather.	3. Calm, fine weather.

The diameter of a temperate cyclonic system is usually about 300 to 400 miles, but in America tropical cyclones,

known as *Tornadoes*, occur over much more limited areas. In tornadoes the isobars are therefore close together, the barometric gradient is very steep, and violent winds do considerable damage. Similar whirling systems that occur in the West Indies are known as *Hurricanes*, and in the China Seas as *Typhoons*. The origins of Tropical and Temperate Cyclones are, however, due to different factors.

EXERCISES

1. Contrast Cyclones and Anticyclones.
2. Explain why the weather in the British Isles is variable, and why, although the prevalent winds are from the south-west, yet at different times during the year winds blow from all points of the compass.
3. Why are the Hurricanes and Tornadoes of the New World more violent than the Temperate Cyclones of Western Europe ?
4. Name the areas of the world having (1) their highest temperature and lowest pressure in July, and (2) their highest temperature and lowest pressure in January. State the direction and cause of the wind systems in each case.
5. What are Monsoons ? Show how they influence the climate of the areas over which they blow.

CHAPTER XXVIII

OCEAN CURRENTS

OCEAN CURRENTS are streams of relatively warmer or colder water crossing the oceans. Their direction can be traced by floating material ; thus tropical mahogany logs from the West Indies have been picked up on the coasts of Norway. Winds are the chief cause which determine the direction of Ocean Currents.

In South Kensington Museum is a model of the Atlantic Ocean. The relative force and direction of the winds are made to act on the waters of this model by means of air, forced by bellows through bent tubes. If the surface of the water be covered with sawdust, it is found that the water drifts in the same direction as it does in the Atlantic

Ocean, thereby proving that wind is the cause of ocean currents.

It should be noticed that it is not really the ocean currents that warm or cool the neighbouring land, but that the air above these currents is rendered warmer or cooler by them, and it is this air, carried inland, which affects the climate.

Currents of the Atlantic Ocean

In the North Atlantic the North-East Trade Winds drive the waters between the Tropic of Cancer and the

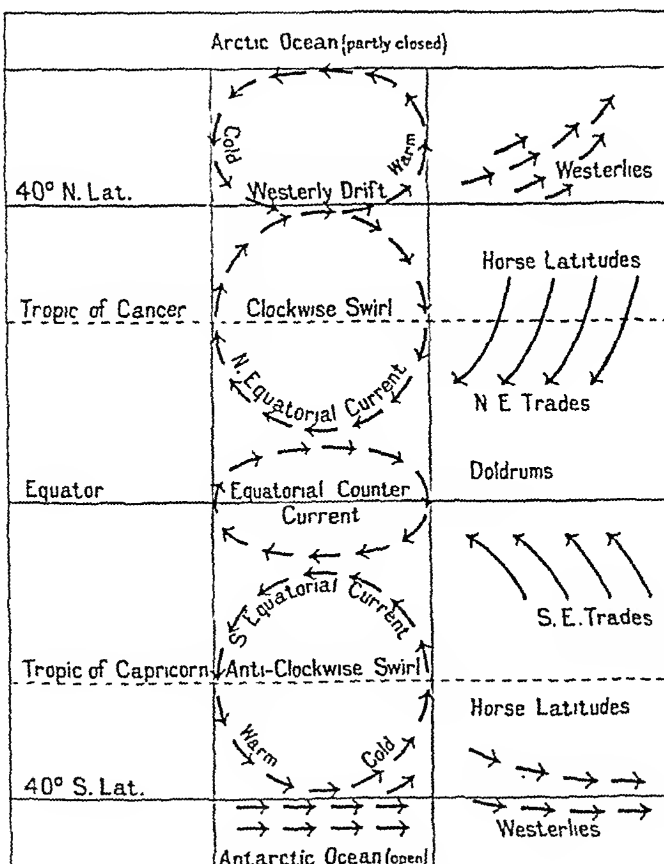


Fig. 57.—Ocean Currents.

Equator in a westerly direction, forming the *North Equatorial Current*. The greater part of this current turns northward at the West Indies and flows along the sea-

board of North America, but part enters the Caribbean Sea and Gulf of Mexico, passing out through Florida Strait to join the previous current. Hence the name *Gulf Stream* is given to this current. At latitude 40° N. it feels the influence of the Western Storm Winds, and is carried across the Atlantic towards the shores of Europe as the *Gulf Stream Drift.*

When the Gulf Stream Drift approaches the shores of Europe it divides, the main portion bending southward past the Azores and the Canary Islands, and finally by linking up with the *North Equatorial Current* forms a continuous clockwise swirl. The other portion passes northward along the shores of Western Europe, sending branches towards Iceland. A cold stream of water, known as the *Labrador Current,* flows southward between the coasts of Greenland and Labrador.

Owing to the direction of these ocean currents, icebergs are not found on the European side of the Atlantic, but they are a menace to shipping, especially in spring, in American waters. The cold Labrador Current carries along quantities of Arctic ice-floes, upon which seals travel southward to Newfoundland waters.

The meeting off Newfoundland of the warm air above the Gulf Stream with the cold air above the Labrador Current provides the ideal conditions for creating fog, namely, moist air suddenly cooled.

In the South Atlantic Ocean the South-East Trade Wind drives the *South Equatorial Current* across from the coast of Africa towards the projecting angle of north-eastern Brazil. Here it divides, the more northerly branch following the coast of the continent into the Gulf of Mexico, where it joins the *North Equatorial Current,* while the southern portion (*Brazil Current*) follows the coast of South America southward to latitude 35° S. It is then carried by the Westerlies back across the Atlantic to the shores of Africa, where it is joined by a cold drift current from the Antarctic Ocean. Following the coast of Africa northward as the *Benguella Current* it joins up

with the *South Equatorial Current*, completing an anti-clockwise swirl.

Notice that, between the North and South Equatorial Currents an eddy, or back current, known as the *Equatorial Counter Current*, flows eastwards into the Gulf of Guinea.

Currents of the Pacific Ocean

The general circulation of the surface waters is similar to that of the Atlantic Ocean. The *North Equatorial Current*, flowing from Mexico towards Asia, turns northward along the shores of that continent as the warm *Japanese Current*, corresponding to the Gulf Stream. This current is carried by the Westerly Winds back across the Pacific, and turns southward off the Western coast of Canada to link up with the Equatorial Current and complete the clockwise swirl. A cold Arctic drift (*Kamchatka Current*) flows south through Bering Strait in the same manner as the Labrador Current does in the North Atlantic. In the South Pacific, as in the South Atlantic, there is an anti-clockwise swirl. A warm current, corresponding to the Brazil Current, flows southward down the eastern shores of Australia, and a cold current (*Peruvian Current*), corresponding to the Benguella Current, flows northward up the western coast of South America.

The wide channels of Davis Strait between Greenland and Labrador allow a free passage for drift ice to enter the North Atlantic, but, as Bering Strait is narrow, floating ice is not encountered in large quantities on the Asiatic seaboard as it is on the American coast.

An *Equatorial Counter Current* separates the North and South Equatorial Currents in the Pacific as in the Atlantic Ocean.

The Currents of the Indian Ocean

In the Indian Ocean only the anti-clockwise swirl, south of the Equator, is complete. The warm *Mozambique Current* washes the eastern seaboard of Africa and Madagascar, while a colder return *West Australian Current*, influenced by a drift from the Antarctic Ocean,

sweeps up the west coast of Australia. North of the Equator the circulation of the surface waters is controlled by the monsoon winds, which reverse the direction of the currents according to the season.

In the Antarctic Ocean there is a drift of water from west to east, driven by the Roaring Forties. This drift contains icebergs from Antarctica, many of which are swept into the anti-clockwise circulation of the Southern Pacific and Southern Atlantic. These are a danger to shipping, especially off the coasts of South America.

Notice that the east coasts of Africa, South America (Brazil), and Australia are warmed by air from off the southward trending ocean currents, while the western shores of these continents are rendered cooler by air made cold by passage over the northward return currents.

EXERCISES

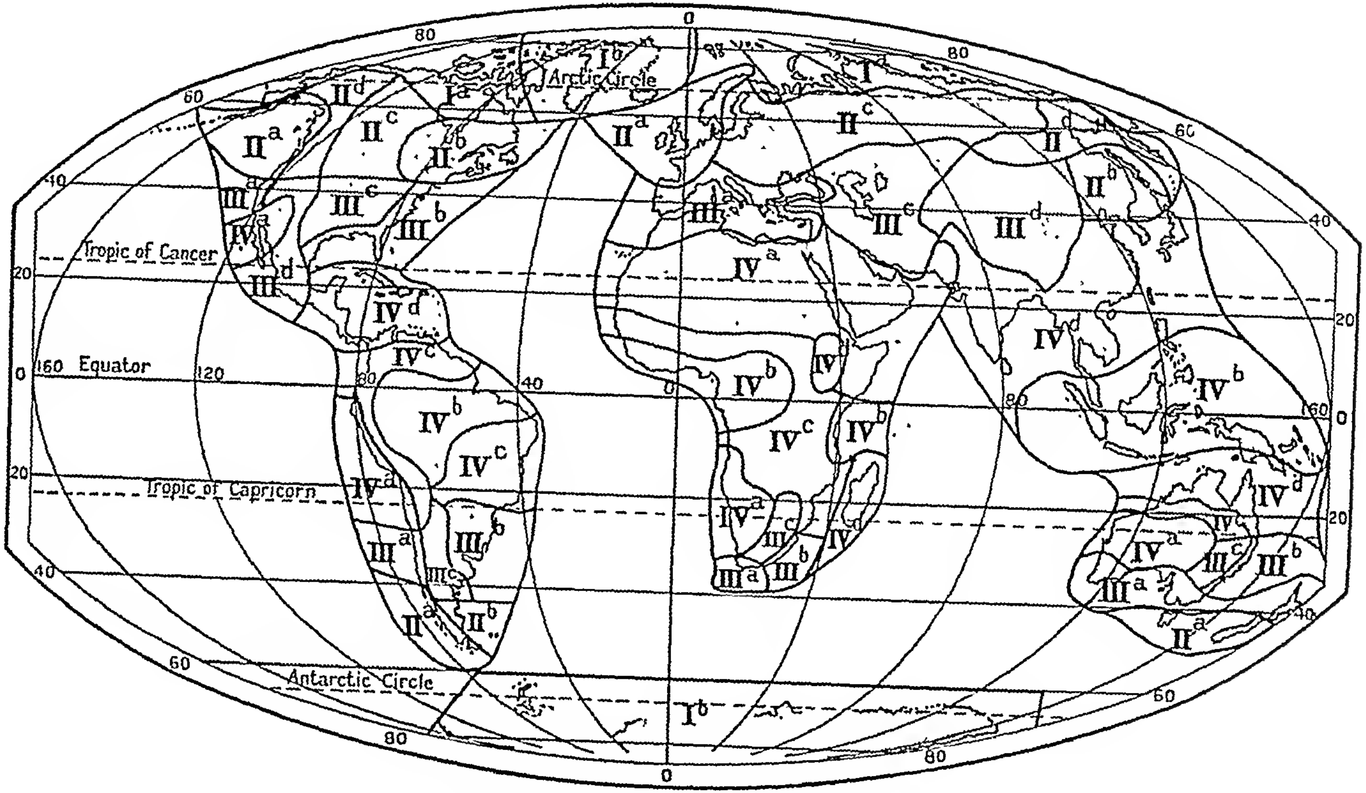
1. Draw any comparisons you can between the currents experienced in the southern Atlantic, Pacific, and Indian Oceans.
2. Compare the currents of the Atlantic and Pacific Oceans. Explain why more drift ice is found in the North Atlantic than in the North Pacific.
3. Describe the route of (*a*) a sailing vessel, (*b*) a steamship to India. In each case name the winds and ocean currents experienced on the route.
4. Draw a map of the world south of the Equator, inserting the wind systems and ocean currents.

SECTION VI.—THE CLIMATIC REGIONS OF THE WORLD

CHAPTER XXIX

ARCTIC LANDS

IN Chapter VII we divided the world into zones dependent upon the slope of the sun's rays, and in Chapter XXVI into climatic belts dependent upon the



MAP 8.—CLIMATIC REGIONS OF THE WORLD.

wind systems of the world. In this and later chapters we intend dividing the world into climatic regions by combining the two divisions we have already studied, and by seeing how far they are modified by the influences of land and sea and also by elevation.

CLIMATIC REGIONS OF THE WORLD

Seasonal Division.	Division by Wind Systems.	Complete Climatic Division.
Arctic and Antarctic Zones.		I. Arctic Lands : (*a*) Lowlands. (*b*) Highlands.
North and South Temperate Zones.	Westerly Wind Belts.	II. Cool Temperate Lands : (*a*) Western Coastal. (*b*) Eastern Coastal. (*c*) Interior Plains. (*d*) Interior Plateaux.
	Winter Rain Belts.	III. Warm Temperate Lands : (*a*) Mediterranean Type. (*b*) Eastern Coastal. (*c*) Interior Plains. (*d*) Interior Plateaux.
Torrid Zone	Trade Wind Belts. Summer Rain Belts. Equatorial Belt.	IV. Hot Lands : (*a*) Trade Wind Deserts. (*b*) Equatorial Lowlands. (*c*) Summer Rain Lands. (*d*) Monsoon Type.

Arctic Lowlands

Bordering the Arctic Ocean and stretching southwards as far as the Temperate Forests is a belt of barren desert, known as *Tundra* in the Old World, and as the Barren Lands in North America. In these regions, where the ocean on the north, frozen for the most part, can exert little influence, the great climatic factor is the slope of the sun's rays. There are two seasons only, a dark, dreary winter, when all the land is buried under snow, and a bright summer, when the sun is above the horizon for the greater part of the day. As, however, the sun's rays are very oblique, they have little heating

power. The ground only thaws at the surface, and consequently the only possible vegetation is such surface growths as lichens and mosses, with stunted trees in the deeper soils along the river valleys. In summer these surface growths make a brilliant carpet of bloom, the land thaws on the surface and becomes a marsh, the rivers overflow and teem with fish, birds are plentiful on their northward migration from warmer lands, and insect life becomes a veritable pest.

The people of the Arctic Lowlands, unable to grow crops, eke out a bare existence by fishing in the streams in the summer and by hunting on the forest edge in winter. They are forced to wander from place to place to find fresh supplies of food, and their usual habitation is a rough tent made of a few poles and the skins of animals. Sometimes, during a lengthened stay in winter, they build snow huts. The children, being required at an early age to assist in obtaining food supplies, receive no education; the infirm and sick cannot receive proper attention and are often left to perish. Under these circumstances civilisation is backward.

In the Tundra of the Old World the *reindeer* is the only domestic animal. It is both horse and cow to the Tundra-dweller when alive, and when dead provides him with food and clothing. The *Caribou* is the North American variety of reindeer, but cannot be tamed.

The southern boundary of the Tundra does not follow any definite parallel of latitude. It lies relatively far north in Western America and Europe, because there, westerly winds from the ocean carry inland a mild climate and the possibility of vegetation ; but in Asia, away from the influence of the sea, the Tundra reaches much farther south. In Eastern North America, where the prevalent winds blow from a cold land mass to the sea, it reaches south to Hudson Bay and Labrador.

Arctic Highlands

The chief areas to be classified as Arctic Highlands are Antarctica (the continent lying round the South Pole), Greenland, and the other mountainous islands of North America.

The effect of elevation is to make these regions even colder than the Tundra. Hence little is known about the interior of these lands, other than information obtained by Arctic explorers such as Nansen, Amundsen, Scott, Shackleton, and Peary, in their journeys overland to reach the North and South Poles. The coasts of these lands, however, are frequented by fishermen in search of whales and seals. Much of the interior is covered with ice, and great glaciers reach the coast without melting, giving rise to icebergs which are carried towards warmer lands by ocean currents.

EXERCISES

1. Describe the life of the Tundra Dweller. Why is he so backward and uncivilised ?

2. On a large blank map of the world mark the Arctic Lowlands and cover them with dot shading. Mark and name the Arctic Highlands, but do not shade these areas. Keep this map and fill in the remainder of the world from succeeding chapters.

CHAPTER XXX

COOL TEMPERATE LANDS

IN this chapter we are to study those parts of the Temperate Zone which fall within the belt of the Westerly Winds throughout the year. In the previous chapter it has been noted that the influences of land and sea and of elevation cause division of these areas into Western and Eastern Coastal Lands, Interior Plains, and Interior Plateaux.

Western Coastal Lands

Mark on a blank map of the world, Western Europe (north of Spain and as far east as 15° E.), Western North

America (as far west as the Coast Range and as far south as *the lower basin of the Columbia River*), *Southern Chile* as far north as 36° S. (South America), Tasmania (Australia), and South Island, New Zealand. In any of these lands you would find a climate similar to our own ; the temperature would be equable, and the same clothes you wore at home would be quite suitable. The weather would vary in much the same way, and the rainfall would be adequate, and fairly evenly distributed throughout the year. Coniferous trees, such as the pine, fir, and larch, and deciduous trees such as the beech, birch, elm, oak, and chestnut, would be found in the woods, while wheat, barley, and oats would be grown by the farmer. Fruits, such as are found in Britain, would be in evidence, as well as root crops like potatoes, turnips, and beetroot.

To understand the reason of this similarity, we must remember that in each of these regions the prevailing winds blow from the sea to the land, causing an equable climate with little range of temperature. As a result, the coasts of these lands are ice-free all the year, and commerce is not stopped by ice. These same winds bring the products of evaporation from the air above the sea to the land, and this saturated air, in rising to cross mountains, causes rain. In all these areas the frequent passage of cyclones produces a variable climate.

Coniferous trees are found in the more northerly lands and at higher elevations. These give place to deciduous trees where the climate is warmer. In the British Isles and Western Europe generally, forests have been largely cleared from the lower lands to provide land for agriculture, and the chief forests are now found on the mountain slopes. In western Canada there are large forests which yield much valuable timber for export. In southern Chile, as the result of exposure to strong winds, the trees are stunted.

The Western Coastal Lands of Europe, that is, those which experience a Maritime Climate, are, broadly speaking, the British Isles, most of France, Belgium, Holland, Denmark, and Norway. It is only gradually, however, that climate in Europe becomes more extreme, and rainfall

becomes less towards the interior of the continent, where conditions merge into the climate of the Interior Plains.

In South Island, New Zealand, the Southern Alps intercept so much of the rainfall that the Canterbury Plains, to leeward of them, are sufficiently dry to supply rich pastures for sheep.

Photo.] [G. P. Rusk.

FIG. 58.—CONIFEROUS FOREST IN VANCOUVER ISLAND, BRITISH COLUMBIA.

Eastern Coastal Lands

On your blank map of the world mark Amuria and Manchuria (Eastern Asia), Eastern Canada and New

England, and Patagonia (South America). These lands present a striking contrast to the Western Coastal Lands. Patagonia is almost rainless, for the westerly winds from the Pacific are intercepted by the barrier of the Andes, and deposit their moisture before they cross it. In Eastern Asia rainfall is due to the same factors as in the Monsoon Lands proper (p. 153), but winters are much longer and colder, as no mountain barriers protect from the bitter winds blowing outwards from inner Asia. Vladivostok, the northernmost port on the coast of Eastern Asia at which it was possible to terminate the Trans-Siberian Railway because it is free from ice, is in the latitude of Southern France.

In Eastern North America the prevailing westerly winds blow from land seaward, causing great extremes of temperature. Hence Labrador, which lies in similar latitudes to the British Isles, is clothed with stunted trees, and cannot grow the products of our country, while the St. Lawrence estuary, in more southern latitudes, is frozen for four months of the year. Conditions, however, are less extreme than in Eastern Asia, because this area lies in the track of cyclonic storms which cross the North American Continent. Their approach is marked by south-east winds, which, blowing from the sea, cause rainfall and bring a modifying influence from the sea. The absence of lofty mountain barriers also allows of the passage of warm air from the south. Rainfall in the Eastern Coastal Lands is much less on the average than in the Western, but gives enough moisture for forest growth. As some of this falls in the form of snow, it waters the ground, when it melts in the spring, more amply than an equivalent amount of rain would do.

The natural forests in these areas have not all been cleared, as the climate and soil conditions are in many places unsuitable for agriculture. In both Asia and Canada the northern forests are composed of small trees or brush-wood, unsuitable for lumber. These forests are the home of many fur-bearing animals, such as bear, marten, sable, silver fox, beaver, mink, and skunk.

The southern forests of Eastern Canada yield valuable supplies of timber. This is cut down in winter and conveyed over the frozen, snow-covered ground to the nearest river. The logs are piled up on the ice-bound river, and, when this melts in spring, the timber is carried downstream to the nearest waterfall. Here it is collected, and saw-mills, using water-power from the falls, cut the trunks into planks. Doors and window-frames are made in large quantities, and in recent years there has been a rapid increase in the manufacture of wood-pulp. This is used largely in the manufacture of paper, and also for many other purposes.

A cold winter and a warm summer and naturally fertile soil afford favourable conditions for cereal farming in Manchuria. This area grows soya beans, wheat, and maize.

Drought in Patagonia, and the action of the winds, after they have crossed the Andes, in stripping from the surface of the land all the best of the soil, make the country suitable at best for sheep pasture.

Interior Plains

These regions are found in the centres of the great land masses of the Old World and of North America. Mark on your blank map Eastern Europe, Siberia (Asia), and the Central Plains in Canada and the Upper Mississippi Basin (North America). Notice that, south of the 40th parallel of south latitude, there are no large land masses, and hence there are no examples of these regions in the southern hemisphere. If you look at Map 4, you will find that all these areas have an average January temperature below freezing point, while parts average $-30°$ F. It is difficult for us to imagine such temperatures, but it should be remembered that the dryness of the climate makes them more bearable. In summer (Map 5) the temperatures do not fall below 50° F., and in some parts reach nearly 80° F. These great extremes of temperature are due to distance from the sea. The intense cold of winter creates areas of high atmospheric pressure, from which cold winds blow outward (Map 6).

The rainfall is about half that experienced in the

British Isles, but, as some is precipitated in winter in the form of snow, little is lost by evaporation when the spring thaws set in. As a result, there is a continuous belt of temperate forest stretching from the shores of the Baltic Sea in Europe to the Pacific shores of Asia; and in North America a belt stretches diagonally across the continent from the far north-west to the St. Lawrence estuary. These belts of forest lie between the barren Tundra of the Arctic Lands and grasslands on the south, which also belong to this division of Interior Plains.

There is a change in the nature of these forests similar to that described under the Eastern Coastal Lands—from stunted trees on the Tundra edge to magnificent forest trees farther south. In the northern forests the timber is of little value, but there, as in Eastern Asia and Eastern Canada, roam numbers of fur-bearing animals. Here the trapper leads a lonely life, his only link with civilisation being a visit from some trader who exchanges the skins he has obtained for the requisites of a civilised life. Towards the south the timber grown is of great commercial value.

Still farther south the forests give place to temperate grasslands. The chief grasslands in Eastern Europe are the Plains of Hungary and Southern Russia. They form an extension westwards of the great grasslands of Asia, which stretch as a broad belt across the centre of the continent south of the Temperate Forests. In North America grasslands reach from the Great Lakes to the foothills of the Rockies. The grasslands of the Old World were once occupied largely by nomadic herdsmen, moving from place to place to find fresh supplies of grass for their horses, cattle, and sheep. To-day a very fertile belt of soil—the Black Earth belt—which extends for 3600 miles from Rumania to Lake Baikal, grows wheat, oats, and sugar beet. Its level surfaces are well suited for the employment of modern agricultural machinery and methods of seed selection. Similar conditions prevail in North America. In the Western Plains of Canada it has been found possible, by selecting early-ripening types of grain, to grow wheat as far west as the Rockies. Between them, the grasslands of the United States and Canada raise one-quarter of all the world's wheat, the western

limit of growth being the annual isohyet of 15 inches, and the northern limit being determined by the occurrence of early frosts.

Interior Plateaux

These are found in Eastern Siberia, where ranges of mountains trend towards Behring Strait, and in North America, between the Rocky Mountains on the east and the Cascade and Coast Ranges on the west. Mark them on your blank map. The climate of these plateaux in Asia is similar to that of the Interior Plains, but is even more extreme, because of greater elevation. The lofty edges of the plateaux intercept rain-bearing winds and prevent much moisture reaching their interiors. In southern British Columbia, for instance, the Fraser Plateau has the loftier Rockies and Coast Range on either side. In these mountain boundaries, however, rise streams which derive their water from the melting snows. They drain across the Plateau, and, by utilising their waters for irrigation, cultivation of cereals and root crops has been brought about.

Man in the Temperate Forest

In this chapter we have learned that the natural vegetation of a large part of these latitudes is temperate forest, of which, however, in Europe especially, large areas have been cleared for agriculture. We have also noticed that the chief occupations in these forests to-day are the cutting down of timber and sawing it into planks, the making of doors and windows, and the manufacture of matches and wood-pulp. In the more thinly forested areas nearer the Arctic Lands we have learned how the trapper leads a lonely life, trapping animals for the sake of their furs. These forests have their influence on the dwellings of the people. The backwoodsman lives in a log hut, and the Swiss inhabit picturesque wood chalets.

The original dweller in the forest lived precariously by hunting and fishing. Sometimes, however, in a clearing

in the forest he grew a few cereals and other crops to supplement the products of the chase. So long as he was only a hunter, the forest dweller was a nomad, compelled to move from place to place in search of fresh supplies of food ; but, finding his crops produced a more certain food supply, he gradually settled down to an agricultural life. This settled life was the first big step in civilisation. With settlement came an interchange of labour. Each man developed that particular work in which he excelled and exchanged it with his neighbours for what they had to offer, and hence trade began. As each product was not of the same value, it soon became necessary to have some method of measuring value ; hence arose the need for money. Later it was found that soil and climatic conditions in one area made it possible to grow more of one crop than that locality required, but that it was impossible to grow other products which were needful. In another settlement near by these crops were perhaps plentiful. Hence there was a further impetus towards exchange and the beginnings of commerce. A meeting-place convenient for the exchange of goods would grow naturally into a market village or market town.

In the past there has been much wasteful felling of trees and loss by forest fires, but, with the present demand for timber, re-afforestation schemes have been started in many forest areas. Young trees are planted each year to take the place of those which have been felled, and only trees which have reached maturity are cut down. In Canada's lumber region, in order to keep up the future timber supply, a day is set apart in each year when children plant young trees. These will provide future supplies of timber in the years to come.

EXERCISES

1. Colour the Cool Temperate Lands on your blank map a light yellow and show by vertical shading the Western Coastal Lands, by horizontal shading the Eastern Coastal Lands, by dot shading the Interior Plains, and leave the Interior Plateaux blank.
2. Contrast the climate and vegetation of the Western and Eastern Margins of the Cool Temperate Lands.
3. Describe the Temperate Forest Areas and explain the uses to which their timber is put. What is Re-afforestation ?
4. State the chief cereal and other crops grown in the Cool Temperate Lands. Name areas where cultivation is made possible by irrigation.

CHAPTER XXXI

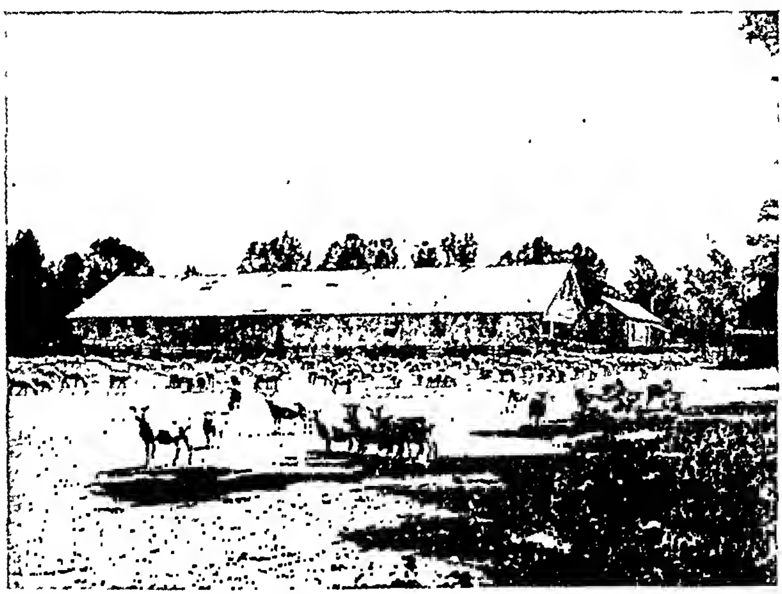
WARM TEMPERATE LANDS

IF climate depended only upon latitude and upon wind circulation a result of the migration of the Thermal Equator would be that all lands lying between the parallels of 30° and 40° would feel the influence of the Westerly Winds in winter and the Trades in summer. They would therefore experience the "Mediterranean" type of climate—that is, mild winters with occasional rain and hot, dry summers. Owing, however, to the distribution of land and sea and the obstacle to wind movement presented by mountain barriers, the true "Mediterranean" type of climate is limited mainly to the western margins of continents between the 30th and 40th parallels of latitude, the interiors of continents within these latitudes being grasslands or deserts deficient in moisture, and their eastern coasts receiving most of their rain in summer.

Western Coastal Lands

Using the same blank map as in the previous lesson, mark carefully those lands of Southern Europe, Western Asia, and Northern Africa that are washed by the Mediterranean Sea, also Upper California (North America), Middle Chile (South America), the extreme south of Africa in the neighbourhood of Cape Town, the south-west corner of Western Australia, southern South Australia, Victoria, and North Island, New Zealand. Each of these areas has the true "Mediterranean" type of climate, because Westerly Winds blow in winter from the sea, causing a mild, wet winter, while the Trades of summer are blowing across land and arrive as drying

winds. This latter condition is not strictly correct as regards North Island, New Zealand, which receives rain during summer from south-easterly winds because they blow across a wide ocean belt. Owing to the lack of frost, evergreens flourish, and these, with such deciduous trees as the chestnut and the walnut, form the chief forms of tree growth. These evergreens have thick leathery or hairy leaves, to lessen evaporation during the summer drought, and elaborate root systems, by means of which they draw moisture at this season from the deeper layers of the soil.



Photo] [*High Commissioner for New Zealand.*

FIG. 59.—SHORN SHEEP AND SHEARING SHEDS, NEW ZEALAND.

Winter in these regions resembles spring in the British Isles, and wheat sown in the winter is harvested in the early summer. The *long, hot, dry summer* enables such fruits as the vine to ripen. Such sub-tropical fruits as the orange, lemon, peach, and apricot flourish in these areas, and in the drier parts figs and dates are plentiful. The olive is the chief evergreen tree, and the oil obtained from it is a valuable food for the people of these lands.

Notice the extent of the region of "Mediterranean"

climate around the Mediterranean Sea—much greater than in any other quarter. This is due to the presence of great water areas which allow westerly winds to penetrate far into the land, instead of mountain barriers which repel them.

The greater elevation, and therefore greater rainfall, of the East Australian Highlands in Victoria allows the growth of hardwood timber of commercial value. Unlike the typical "Mediterranean" region in Europe, also, the "Mediterranean" region of Australia in Victoria pastures cattle in large numbers as well as sheep, while North Island, New Zealand, contains approximately the same number of sheep as does South Island.

Eastern Coastal Lands

Insert on your blank map the following regions: the Atlantic Plain of North America south of New England and the Gulf Plain facing the Gulf of Mexico; the seaward slopes of the East Australian Highlands as far north as the Tropic of Capricorn; the seaward slopes of the escarpment of the South African Plateau from Mossel Bay to Delagoa Bay; Brazil south of the Tropic of Capricorn, Uruguay, and the basin of the lower Parana. China and Japan lie in these latitudes, but are Monsoon Lands, and will be dealt with later.

The Westerly Winds in these areas blow in winter from land to sea, and not only can carry no sea influence but even convey land influences from the interiors of the land masses to the coasts. The Trades in summer are drawn in from the sea to low pressure systems that have formed over the lands, and in many respects resemble monsoon winds.

Trade Winds, as we know, are usually productive of dry climatic conditions, but when they blow across wide areas of ocean, they too become moisture-giving winds. It so happens that, when they meet these Eastern Coastal Lands in Australia and South Africa, they are compelled to rise, a short distance inland from the coasts, in order to cross respectively the East Australian Highlands and the raised escarpment of the South African Plateau. These

barriers thus entrap most of their moisture, and little reaches the interiors of the continents beyond them. The same result is produced in Brazil by the barrier of the Serra do Mar.

Crops grown are largely tropical or sub-tropical in type—cotton and tobacco in North America; cotton, sugar, and tobacco in South Africa. Uruguay and Southern Brazil, however, raise cattle; while in Australia there is an important dairying industry in the coastal belt.

The elevation of the Appalachians and the East Australian Highlands secures them a rainfall sufficient for the growth of forests. In South America there is the important Quebracho forest in the basin of the Parana.

Interior Plains

These stretch across the Old World from Syria and Mesopotamia in the west to the Interior Plateaux of Asia in the east, and across North America from the Rockies to the Appalachians. Mark these areas on your blank map. South of the Equator mark also the westward drainage slope of the East Australian Highlands, the eastward drainage slopes of the Andes as far north as the Tropic of Capricorn, and the eastern half of the South African Plateau.

Except in North America east of 100° West longitude, where there is sufficient rainfall, chiefly in summer, to make agriculture profitable, these are mainly grasslands or steppes. The barrier of the Western mountains in North America, and in Asia the vast distance from the ocean, prevent any moisture reaching them with the Westerlies; whilst in Asia the western section of these Plains lie in the sphere of the Trade winds, whilst Central Asia receives very little rain from monsoon winds which have crossed the great mountain barrier. As Central Asia is a region of great summer heat, what rainfall it receives is in places insufficient even for the growth of grasses, and desert conditions result. In the same way, as already noticed, the East Australian Highlands and

the escarpment of the Plateau in South Africa intercept moisture before it can reach the plains behind. The Central Low Plains, however, of North America, east of 100° W., have a considerable rainfall from moisture-laden air drawn inland from the Gulf of Mexico.

Over the Western Plains of North America once roamed huge herds of wild buffaloes. To-day they are great cattle-producing areas, and in parts, where irrigation is possible, are being converted into agricultural lands. Cattle are also raised in great numbers in Argentina, as well as wheat, maize, and flax.

On either side of the Upper Mississippi Basin, from the latitude of Chicago to that of St. Louis, is the great Maize or Corn Belt of the United States. Southward of the Corn Belt lies the Cotton Belt, raw cotton being the most important export of the United States.

What water can effect to bring about fertility in areas naturally barren has been shown in Mesopotamia—the land between the Tigris and Euphrates—where from very early times a system of irrigation canals has been in existence.

East of Mesopotamia is the Plateau of Iran, consisting of Afghanistan and Persia. In this area, owing to the dry climate, the rivers fed by the mountain glaciers dry up before reaching the sea. Much of this area is poor grassland; and the settled population lives mainly in the valleys, where the rivers leave the mountains to cross the plateau.

Interior Plateaux

Mark on your blank map the plateaux which separate the Rockies from the coast ranges of Western North America, also the Plateau of Mexico, and the interior highlands of Asia. The rainfall is scanty except on the more lofty mountain buttresses, and the climate is very extreme. Poor grassland or desert covers most of these regions, and agriculture is only possible in the deeply trenched valleys, watered by mountain streams.

Tibet, a large plateau about three miles high, lies to the north of India, and, because of its elevation, is one of the cold deserts of the world. Its steep, buttress walls

prevent the monsoon rains from reaching its interior, and what little moisture falls, is precipitated in the form of snow. The scanty population, shut out from the civilisation of the world, is extremely backward. The yak, a one-humped ox, in some respects resembling the camel, is the chief domestic animal.

An increased rainfall along the northern edge of the Tibetan Plateau results in a belt of vegetation, known as the Curtain of Tibet. This is followed by the caravan routes from China to Central Asia. The Plateau of Mongolia and the Tarim Depression to the west of it, although not so elevated and cold as Tibet, are subject to great extremes of climate, and form grasslands or deserts.

Man in the Steppe

Both in this and the previous chapter we have learnt that extremes of climate and deficiency of rainfall cause a large proportion of the Interior Plains of the world to be unfit for agriculture. Both the heat and drought of summer and the cold of winter destroy vegetation. Only such plants can live as quickly spring into life and as quickly reach maturity. For this reason these areas are, at their best, grasslands of poor quality—that is, Steppes.

The dweller of the Steppe is a nomad, wandering from place to place to find water and grass for his flocks and herds. The dry, pure atmosphere and his open-air life make him strong and hardy. He counts his wealth by the number of his flocks and herds, and, as these require a continual attention, he is anxious to keep his children with him when they grow up. In this respect life for the nomad of the Steppe differs from life for the nomad of the Tundra, where shortage of food causes the children to leave their parents directly they are old enough to fend for themselves. As he has many beasts of burden, the tents of the Steppe dweller can be much more elaborate than the rough shelter that must suffice for the inhabitant of the Tundra, and he is able also to carry on his migrations many articles for his comfort. He has a healthy contempt for the settled life of agricultural peoples, and in this respect, too, differs from the nomad of the Tundra, who is only too anxious to settle down at the first opportunity. The one great danger for the Steppe dweller

is, in bad seasons, failure of his pastures, and when this has happened in the past, the peoples of the Steppes of Asia have entered into history in great invasions of the more fertile lands on their borders in Western Europe, South-Eastern Asia, India, and China.

From the earliest times to the close of the Middle Ages the history of Europe shows a record of constant invasions of more fertile lands in Western Europe by Steppe dwellers from Asia. Huns, Mongols, Bulgars, Magyars, and Turks, all came from Asia. India was subject to many waves of invasion through its north-western gateways, each of which was strong enough to leave its impression on India. Hence India's problems to-day are due to its containing many races of people with differing religions. Similarly, Mongol Steppe dwellers entered China through the Gate of Peking, between mountain and sea, and for over 1000 years dominated that country.

The scriptural narrative provides us with an excellent account of the life of the Steppe dweller. The quarrel between the shepherds of Abraham and Lot over wells, the wanderings of the Israelites in the Wilderness, and their constant complaints about lack of water, the sending by Jacob of his sons into Egypt to buy food, as well as many other incidents, are typical of the life of a Steppe dweller. In a land where the sun is always shining, where a cloud the size of a man's hand is remarkable, and where there are no trees for shade, the shadow of even a rock in a thirsty land is much to be desired, and to be led beside cool waters is the ideal of bliss. The prophecy that "The desert shall blossom as the rose" is a reference to the short-lived change that takes place every spring when, after rain, beautiful bulbous plants burst into bloom. The rich vegetation which clothes the Lebanons and the coastal plain of Palestine within the region of "Mediterranean" climate must have provided a marked contrast for the Israelite, used to the monotonous scenery of the Steppe.

EXERCISES

1. On your blank map of the world colour the whole of the Warm Temperate Lands orange. Mark the Western Coastal Lands by vertical line shading, the Eastern Coastal Lands by horizontal line shading, the Interior Plains by dot shading, and leave the Interior Plateaux blank.
2. What is the "Mediterranean" type of climate? What is

its cause? Name the parts of the world having this climate. State the products grown and the natural causes upon which they depend.

3. Contrast the climates of the Eastern and Western Coastal Lands of the Warm Temperate Lands, giving reasons for the differences you mention.

4. Large parts of the world are devoted to stock-raising. Name some of these areas, and give reasons why this is the main occupation of their peoples.

5. Describe the life of a Steppe dweller and contrast it with that of the Tundra dweller.

CHAPTER XXXII

HOT LANDS

Trade Wind Deserts

IT has been shown in Chapter XXVI that the Trade Winds blow all the year round in a belt roughly between the 15th and 30th parallels of latitude on either side of the Equator. They reach the western margins of continents lying to leeward as dry-weather-producing winds, because they do so after having crossed a land mass, and create desert conditions.

Insert on your map of the world the following deserts, which you will find on the western margin of each continent: The Sahara Desert in Africa, stretching into Arabia and the Thar Desert in India, the West Australian Desert, the Kalahari Desert of South Africa, the Atacama Desert of South America, and the desert states of Colorado, Arizona, New Mexico, and Lower California in North America.

The Atacama Desert of South America lies at the foot of the Andes. Snow-fed streams from the Andes, which cross the desert, floor their valleys with alluvial soil, and

make possible the cultivation of sugar and cotton by irrigation.

Underground supplies of water in the Kalahari Desert enable the Bushmen and Hottentots to keep flocks of sheep on the otherwise poor pasture.

Arabia is occupied by nomadic shepherds, except in the cultivated lands on its seaward slopes.

Rain falls in the Sahara only on the rarest occasions, except on the mountain plateaux, such as the Ahaggar. When it does fall, however, it is stored up in the dry beds of former rivers and in impermeable rocks, and forms the source of water supply for the wells of scattered oases.

FIG. 60—EGYPTIAN. CHILDREN IN THE OASIS OF EL ARISH, SINAI PENINSULA.

Notice the *shaduf* in the background, by which water is drawn from a well for irrigation.

The sand of the Sahara desert is due to the extremes of day and night temperature causing the rocks to expand and contract. This continuous change makes them crumble. Dry winds sweep across the desert and form the sand into ridges known as sand dunes. The soil is naturally fertile, and where water is obtainable, can produce date palms, millet, rice, and fruits. In the desert proper are found coarse grasses and prickly shrubs able to withstand drought.

Life is impossible except in the oases, and journeys can only be made by travelling on camels from oasis to oasis. Arab caravans do much of the trade, exchanging

the products of the more fertile areas on either side of the desert.

Across the wastes of the Sahara the Nile flows from its reservoirs of Lake Victoria and Lake Albert to the Mediterranean Sea. In Egypt, as in Mesopotamia, irrigation canals have been employed from very early times to foster and extend cultivation, when the river, swollen annually by flood water from Abyssinia, lays fertile silt on the fields on both its banks.

Equatorial Lowlands

The Equatorial Belt of Calms produces a régime of constant rains in the lowlands of the Amazon and Congo Basins, in the East Indies, and on the narrow coastal plain of Kenya and Tanganyika in Africa. Mark these areas on your blank map of the world. Intense heat and great moisture cause marshy, malaria-breeding conditions in the lowlands, rendering them unsuitable for white habitation, and these factors are also responsible for the dense undergrowth and giant forests which cover these areas.

Great heat and great moisture combined cause all forms of vegetation to grow to their fullest extent. Giant trees, all struggling upward towards light and air, darken the forests, for the sun cannot penetrate their dense foliage. The ground below is a tangled undergrowth of creepers, through which it is impossible to cut a way. The larger animals cannot live in such a region, and the chief occupants are monkeys, reptiles, and insects. Nature here supplies man with his necessities with a lavish hand. When a native requires a little manioc or a few bananas, he burns trees to make a clearance and throws down a handful of seeds, which Nature brings to growth and harvest without requiring any labour on his part. What inhabitants, therefore, there are in such regions are indolent and backward.

The chief natural products of the tropical forests are wild rubber, timber, such as mahogany, teak, and dyewoods, vegetable fats, such as palm oil, shea butter, and ground nuts, and medicinal plants. The natives grow maize, rice, pea-nuts, manioc, bananas, and Kaffir corn in forest clearings.

The moist heat and swampy ground cause these areas to be infected with mosquitoes, whose bite is largely responsible for the malarial fevers so dangerous to Europeans. Medical science is doing much to exterminate

Photo] [E.N.A.

Fig. 61.—Tropical Forest in the Valley of the Amazon, Brazil.

malaria, and these lands may then become great food-supplying areas.

The influence of the white man in the tropical forest has introduced plantation cultivation in the East Indies of rubber and sugar, in West Africa of cocoa.

Summer Rain Lands

The climate of plateaux within the Tropics varies with their elevation—the more elevated the plateau, the cooler being the climate. As the lowlands are always hotter than the plateaux, winds passing over them are forced to rise by the heated land surface, with the result that the lowlands are constantly subject to heavy convectional rains, and receive a much higher rainfall than the plateaux experience. The vegetation of the plateaux is therefore grassland rather than forest. Ecuador is a grassy plateau, while East Africa is a savannah land, consisting of mixed woods and grasslands. The slopes leading up to the plateaux show different zones of climate and vegetation, varying according to height, from tropical forest at the foot through temperate forest to grassland.

In Chapter XXVI we learnt that the Migration of the Thermal Equator causes a belt of Summer Rains on either side of the Equator. As the rainfall decreases towards the desert, these areas are transition regions, the vegetation varying from tropical forests on the equatorial border to poor steppe lands on the desert edge. In Africa these areas include the east-west belt of the Sudan, and the Horn of Africa, north of the Equator, and south of it the Plateau of the Great Lakes, and the northern portion of the South African Plateau. In South America they comprise the Plateau of Guiana north of the Equator, while south of it similar regions are the Plateau of Brazil north of the Tropic of Capricorn and the Bolivian Plateau. In Australia they include an east-west belt north of the Tropic in Northern and Western Australia. Mark these areas on your blank map of the world.

The natural vegetation of most of these regions is tropical grassland, or *Savannah*, where grasses die down during the dry season of winter and trees become dormant, to spring again into life with the summer rains.

Savannahs are known in South America as llanos and campos. They are due rather to deficient rainfall than

to extremes of temperature. Great quantities of large wild animals roam over these tropical grasslands in Africa—elephants, antelopes, rhinoceroses, giraffes, and lions. In South America and Australia, on the other hand, there is a complete absence of such big game.

The climate on the tropical plateaux is far more healthy than in the lowlands, and the natives are therefore mentally and physically superior. These plateaux are also suitable to some extent for white habitation. Maize and millet are grown on the Plateau of East Africa. Coffee is cultivated on the wetter slopes, while the drier grasslands can be used to pasture sheep and cattle. In South America the relatively cool climate of the Brazilian Plateau makes it also a natural cattle country, while coffee and cotton are cultivated just north of the Tropic in the States of São Paulo and Minas Geraes.

Eastern Margins of Tropical Plateaux

Mark on your blank map of the world the following areas on the eastern margins of these Equatorial Summer Rain Regions: Portuguese East Africa, the coastal plain of northern South America between the Orinoco and Amazon mouths, and the north-east angle of the Brazilian coast.

Each of these regions has summer rain due to its position near the Equator, while in winter the Trades coming from seaward to the land cause rain at that season also. As these areas have rain throughout the year, they are covered with tropical forests, and the coastal plains are capable of producing such products as sugar and spices.

Monsoon Lands

These are summer rain regions, but differ from those of Equatorial Summer Rain in that their rainfall is not due to the seasonal shift of the climatic belts, but to the reversal of the winds from blowing landward in summer to blowing seaward in winter. Monsoon Lands proper have three seasons—Cold Weather, approximately from October to February; Hot Weather, from March to the

end of May; and the Rains, after the "bursting" of the monsoon in June till October. South of the Equator, of course, these months are reversed according to the altered seasons of the year. The Monsoon Lands are India, China, Japan, Indo-China, Northern Australia, Abyssinia, Madagascar, and the West Indies and Central America. Mark these areas on your map of the world. Northern China and Japan obtain their rain from monsoon winds, but have much colder winters than, *e.g.* Southern China, and their climates fall into four and not into the three typical monsoon seasons.

In Chapter XXVII we learned something of the cause of these monsoons and their direction. If the eastern half of Asia were at all one elevation, there would be formed over it a low pressure area in summer, into which the winds would blow spirally. The Plateau of Tibet, however, acting as a climatic barrier, causes the formation of two low pressure centres—one over the north-west of India into which the summer monsoon of India blows, and another over the Plateau of Mongolia, to which blow the summer winds which influence the climates of China and Japan. It should be noticed that in the latter case, the inflowing winds, coming from the south, make the climate of China hotter than it would otherwise be. Similarly the outflowing winds carry cold conditions far south. Thus Northern China has great extremes of temperature.

Your temperature and pressure maps of the world will show that, when there is a cold winter and high pressure over Mongolia, there is a high temperature over the land mass of Australia, which is then experiencing its summer. Hence the winds which blow out of Mongolia blow spirally into Australia. In northern summer opposite conditions prevail, and winds from Australia blow into Mongolia. These winds in passing over the East Indies and south-east Asia bring rain at both seasons of the year, in (northern) summer to the south and east slopes, and in (northern) winter to the north and west slopes.

Northern Queensland and the northward slopes of the Western Australian Plateau get moderate rainfall from the summer monsoons, and, as a result, are forested; but the plateau edge prevents much of this moisture from reach-

ing the interior, the vegetation of which quickly merges into scrub and desert.

A low pressure system over the Sahara, in summer, causes inflowing winds from the Indian Ocean,. which, rising to cross the Abyssinian plateau, bring heavy summer rains to that region. The water from these rains is conveyed along the river gorges to the Nile, causing it to overflow and deposit fertile alluvium on either side of the river. It is this which causes the fertility of Egypt. To-day the flood waters are regulated, so that crops can be grown at all seasons.

As compared with countries of "Mediterranean" climate, summer in Monsoon Lands is a time of both warmth and rain, so that plant growth is faster than in Mediterranean Lands. Sugar cane, rice, cotton, citrus fruits, and the mulberry, therefore, replace olive, vine, and fig as the characteristic cultivated plants.

EXERCISES

1. Colour the Trade Wind Deserts in your map of the world light brown. Then colour all the Equatorial Areas green. Cross shade the Equatorial Lowlands, use horizontal shading for the Summer Rain Areas, and cross line shade the Eastern Margins of these areas. Colour all the Monsoon Regions red. You will now find that every part of the world falls into one of the regions which have been described in the last five chapters.
2. Show the influence of elevation upon climate in tropical regions, and the resulting effects on the vegetation and peoples.
3. Name the Monsoon Regions of the world. How do they differ from the Equatorial Summer Rain Areas?
4. Name the chief Grasslands of the Summer Rain areas and show how they differ as to the causes which produce them from the grasslands of the Temperate Zone.
5. Name the chief Desert Areas of the world. What is their cause? Why is sand found in the desert?
6. Explain why the desert area of the Old World north of the Equator is so much larger than that formed in the rest of the world.

SECTION VII.—MAN ON THE EARTH

CHAPTER XXXIII

NATURAL CONDITIONS INFLUENCING MAN'S DISTRIBUTION, CHARACTER, AND OCCUPATIONS

COMPARE a map showing the distribution and density of population in any region with other maps illustrating the surface relief, climate, and natural vegetation, and it will be apparent that the distribution of man over the earth is determined largely by geographical factors. Geographical factors determine the distribution of mankind because of their influence upon man's occupations, an influence of which we have already seen several examples. They have even some effect upon his character, supplying a partial explanation why here he is industrious and civilised, there idle and ignorant. If we analyse the ways in which geographical factors affect the distribution, occupations, and character of mankind, we shall see that the most important influence at work is that of climate.

Climate exerts its influence in three ways—directly through *Climatic Factors*, such as heat and cold, and indirectly through its effect upon vegetation, and upon insect-carried diseases. You know how little inclined you feel to take active exercise on a very hot, "muggy" summer's day; probably you even feel disinclined to work hard at your studies. In winter, if the weather is bitterly cold, and you are sitting in an unheated room, you equally feel unable to apply yourself diligently to your work, disregarding cold feet and cold hands. It

is easy to realise from your own experiences that an atmospheric temperature which is always very high discourages human effort, and that the effect of continual severe cold is to numb and depress man's faculties.

> In the upper Amazon basin temperature often rises to 130° F. The atmosphere is constantly heavily charged with moisture, so that the jungle seems like a Turkish bath. At night the temperature may fall to 76° F., which in comparison seems bitterly cold. White men can, it is true, live and work for a while under such conditions, but the permanent inhabitants are Indians or of partly Indian descent.

In the second place, Climate effects its influence through *Vegetation.* It is the Natural Vegetation of his home region, that is, the plants that grow without cultivation, which, before man has made much advance in civilisation, provide him with food, and with materials from which he can fashion clothing and a house. When he has learned to till the soil, climate determines what cultivated plants man can grow, and it determines also what animals he can pasture. It is just as important that vegetation should not grow too freely, as that it should not be too scanty; because in the latter case man may not be able to obtain food at all, while in the former case vegetable growth may be so rapid that it chokes the crops he has sown. Man, indeed, can only profitably undertake cultivation when Nature itself checks the growth of vegetation at some season of the year, either by winter cold or by drought. Such a check is given by three types of climate—the Mediterranean with summer drought, the Monsoon with winter drought, and the Cool Temperate, as in Western Europe and Eastern North America, with winter cold. Compare a population map of the world with Map 8, showing Climatic Regions, and you will see that, broadly speaking, it is regions experiencing those three types of climate that are most densely populated.

But food, clothing, and possession of a house are not

enough to ensure an advance in civilisation. If man has no time to think of anything except filling his larder, clothing himself and his family, and keeping a roof over their heads, he can never work out any new ideas, and can make no new discoveries. The beginnings of civilisation for this reason took place in the river plains of the Nile, Mesopotamia, India, and China, largely because in those lands irrigation was easy, and production of crops possible throughout the year. This yielded a surplus of food, beyond what was necessary for the people's daily needs, and this surplus could be traded with other lands.

The dweller in the Tundra, forced to eke out a bare existence by hunting and fishing, is backward, because his utmost efforts can win from Nature only what is hardly sufficient to keep him alive. His brother of the tropical forest equally is backward, because in his case Nature is too bountiful, and satisfies his physical wants in response to a very slight exertion of his mental and physical powers. Man has reached higher stages of civilisation in lands where he has been compelled to think and act to provide for his needs, and in these lands, the more he does so think and act, the more he can gather surplus wealth, which will allow him the opportunity for recreation and improvement.

Climate also affects man's distribution and character through its influence upon *Disease*. Pools and stagnant water in warm countries often form breeding-grounds for the *anopheles* mosquito, which is the carrier of the germ of malaria. Individuals infected with malaria are attacked by the disease every autumn till they reach manhood, and their strength is lessened for life. Whole populations can be affected in this way. Yellow fever, carried by the striped-legged domestic mosquito, is liable to appear during rainy seasons in the tropics, and used to be carried by slave ships to European ports. In Georgetown (British Guiana) nearly seven in every ten inhabitants died of yellow fever in 1840.

Insect-carried disease can affect animals as well as men. In Africa the tsetse fly infects human beings with sleeping

sickness and domestic livestock with the disease called *nagana*. Vast stretches of fertile land in East Africa have been deserted for fear of *nagana*, and cattle-breeding areas cut off from their markets by belts of country through which the cattle cannot pass because of the presence of the tsetse fly.

The construction of the Panama Canal was a triumph for medical science over tropical diseases. The population of the Isthmus had been subject for centuries to plague, yellow fever, and malaria. The carriers of these diseases—rats, fleas, and mosquitoes—were destroyed; modern sanitary methods were introduced; a good water supply was secured. The rooting out of tropical diseases is one great benefit that can be brought to tropical countries by Europeans and Americans.

It is partly their more temperate climates, partly their relative freedom from insect-carried disease, that give importance to the higher lands of the tropics as places of residence for Europeans. India has numerous hill-stations, to which British administrators and business men and their families go during the summer monsoon; while in Kenya, British settlers farm on the highlands, and in tropical South America the capital cities of Bolivia, Ecuador, and Columbia are all placed on the high plateaux of the Andes, 8000 feet or more above sea-level.

It is obvious that as a general rule there is more room for settlement in plains than in mountain valleys, and that the inhabitants of the one type of region will follow different occupations from the inhabitants of the other. What these occupations are will, we know, be decided partly by the climate. We have, however, also to consider how they will be affected by Land Relief, Mineral Resources, and Communications.

Land Relief.—At an early stage of development, a community benefits greatly if it enjoys the protection of natural barriers against invasion, which allows the people to follow their occupations, secure against attack by any foes. Such natural frontiers may be a seacoast, as in the case of Crete; a desert, as in the case of Egypt; or mountains, as in the case of Switzerland. A river seldom makes a good natural frontier, for population

is generally tempted to spread from one bank to the opposite bank.

We have seen that primitive man in the forest was a hunter and food-gatherer, while on the grasslands he was a herdsman. In both cases his occupation forced upon him a wandering life. As the forest became cleared —a process which depended largely upon the discovery of the use of metals, bronze and iron, from which more serviceable axes could be forged as weapons in man's warfare with the forest—the forest-dweller settled down and became a cultivator. The herdsman of the grasslands, on the other hand, fought against such a fate—only, sooner or later, to be swept away and replaced by the cultivator he despised, wherever climate and soil

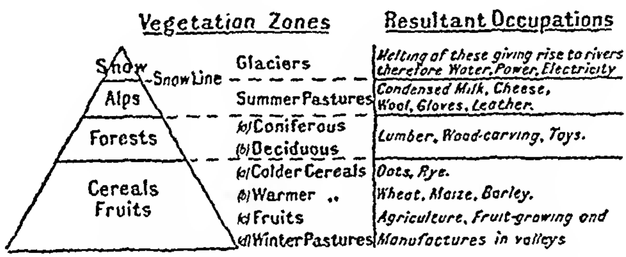


FIG. 62.—OCCUPATIONS IN EUROPEAN ALPS.

were such that a better use could be made of the grasslands by agriculture than by the pasturing of flocks and herds. The lowlands of the globe are thus in general divided to-day between stock-keeping and agriculture, the population of the agricultural regions being much denser than that of the pastoral areas.

The dwellers in a mountain valley are often isolated from the rest of the world. They intermarry with each other, and thus acquire a sense of clanship. They have hardships to endure, and become hardy, brave, and independent. Lack of contact with other peoples tends to preservation of local dialects and distinctive national dress, and to keep alive old customs and superstitions.

Occupations in a highland region are specially dependent upon the natural vegetation, because importation of raw materials is difficult. The grasslands on the

higher mountain slopes pasture cattle and sheep. The forests make possible lumber industry, from which specialised skill may develop such a manufacture as wood-carving. Agriculture is often practicable on the lower slopes of the mountains, where there is a warmer climate, and in sheltered valleys, where the streams may have laid down a richer soil.

Mountain barriers to-day have largely been overcome by the construction of roads and railways, and mountain peoples are less isolated than in the past. The natural beauty of mountain regions attracts visitors, and the roads and railways which bring them can be used to carry also raw materials for expanded industries, dependent upon the highly specialised skill of the mountain folk.

The number of people that can be supported by agriculture in any region depends largely upon the food-giving value of the crops grown. A high summer temperature and heavy summer rainfall make possible the cultivation of rice, which is the tropical cereal which yields the greatest amount of human food from a given area of land. Java, for example, in the Dutch East Indies, because it is a rice-producing country, is able to support a very large number of inhabitants.

In Java, except for half a dozen small towns, the population is evenly distributed in small farms over the whole island, which is roughly the same size as England. In England, on the other hand, only one-fifth of the people live in country districts, while four-fifths of the inhabitants live in greater and lesser towns. It is apparent at once that England, unlike Java, is not mainly an agricultural country; and, in fact, outside the rice-producing countries, no agricultural district contains a very great population. Great masses of people are gathered closely together only where there has taken place development of manufacturing industry and commerce. The possibility of such development depends upon Mineral Resources and Communications.

Mineral Resources.—The nature of the rocks in any region has also important effects upon the distribution and occupations of mankind. In the early days of civilisation the chalk and limestone ridges of southern

England and of the Paris Basin in France were less thickly forested than the clay valleys, because chalk and limestone break up into only a thin soil. For this reason they were suitable for settlement and provided easy means of passing from district to district before man had effective tools with which to clear the forest. In Central Europe and in China the loess soils offered similar advantages. In Canadian history, on the other hand,

[*Central Press Photos Ltd*

FIG. 63.—MINER AT WORK IN A NORTHUMBERLAND COAL MINE.

the hard, infertile rocks of the Canadian Shield, scoured bare of soil by the glaciers of the Ice Age, were an obstacle because they afforded no roads for the settler's wagon westward of the St. Lawrence valley.

We have seen in Chapter X how rocks of economic value, such as coal, slate, and salt, came to be formed, and how underground water, seeking an outlet, may, as mineral springs, brings up deep-seated minerals for deposit at the earth's surface as metallic ores. The distri-

bution of such rocks and ores over the earth's surface is a result of the past history of the globe. Coalfields are found to-day where forests once flourished on the marshy river-deltas of ancient coastlines. Hot springs found their way to the surface most readily along the rims of hard, resistant land-blocks (see Chapter XV). Geologists know the principles in accordance with which all minerals are distributed, and their knowledge is continually making available new sources of mineral wealth for man.

The two minerals which have been of greatest importance for the development of manufacture, and thus for determining the present distribution and occupations of mankind, are coal and iron. Countries which possessed both coal and iron in large quantities became industrial communities, and their populations were grouped in a relatively small number of large towns.

In recent times other metals, such as tin, copper, aluminium, zinc, have come into greatly increased demand. This has had the result of establishing mining communities wherever the ore occurs, in localities which otherwise might have had no inhabitants, as at the copper mines in the Peruvian Andes, 14,000 feet above sea-level.

If, as we have seen, only one-fifth of the population of England is "rural," that is, engaged in agricultural and pastoral occupations, it is obvious that English soil cannot to-day be producing all the food which the workers in English factories and their families eat, or all the raw materials which they turn into manufactured goods. It will further be obvious, on a moment's consideration, that under no circumstances could certain of these foods and raw materials, such as cocoa and cotton, be produced in England, because the climate is unsuitable. As the same is true of all great industrial communities, it is clear that *Means of Communication*, by which food and raw materials are borne to industrial centres, and manufactured goods are carried from these centres to the

purchasers, are also an essential factor in determining the occupations and distribution of mankind to-day.

EXERCISES

1. In what ways does climate influence the distribution and occupations of mankind to-day ?
2. Do climatic influences alone explain the distribution of the most densely settled areas of the globe ?
3. Name six main occupations followed by mankind, and one country in which each is important. State to what geographical factor each has been mainly due.

CHAPTER XXXIV

THE SITES OF TOWNS

Growth of Towns

IN early ages the site of a settlement was decided by the presence of an ample supply of food and water, and by natural defensibility, which provided security from sudden attack by hostile tribes. These first settlers were agriculturists, growing crops and keeping some cattle, sheep, and fowls. Such settlements were only villages. The first towns to spring up were situated at the convergence of routes, where people could meet to exchange the different products of their districts. A number of such towns were seaports, where land routes and seaways met. Thus most of the older towns are market-towns. Industrial towns date from a much later period, when the use of coal to generate steam power brought about the system of manufacturing goods in factories, instead of in the homes of the workers. These towns grew up near or on the coalfields, or where some inheritance of skill or some natural advantage, such as an

abundant supply of raw material, favoured the development of a particular industry.

Ford and Bridge Towns.—In early days routes converged on that point where a river could be forded, and there a "ford town" sprang up. At a later period bridges took the place of fords. *Oxford* and *Cambridge* are examples of such towns.

Confluence of Rivers.—Towns tend to grow up where two or more rivers meet, because roads follow river valleys as the path of least difficulty, and the meeting-point of the valleys probably forms a good trade centre. Later railways followed much the same routes as did roads. Thus to-day *Reading* stands at the meeting point of lines of river, road, and rail traffic. *Coblentz* on the Rhine, and *Lyons* on the Rhône are other examples.

Limits of River Navigation.—Towns at the limit of navigation from the sea are important because there transport by water must be replaced by transport by road or rail. Routes will also converge on such points, so that goods may make use of water transport, which is usually cheaper than land transport. *Shrewsbury* on the Severn, *Prague* on the Moldau in central Europe, and *Duluth* on Lake Superior in North America, are examples of such towns.

Limits of Ocean Navigation.—When vessels were much smaller than they are to-day, ocean navigation reached farther up the river estuaries, and the limit of ocean navigation was also often the position of the lowest bridge on the river. *London* was the bridge-port of the Thames, and the transfer of foods from sea-going vessels to river craft or to road carriage, made the city a centre of trade.

River-Bends.—Roads and railways generally follow river valleys where possible. Hence, at a bend in a river, some routes, which have previously followed the river, leave it, while others join it. *Orleans* on the Loire in France, and *Henley* on the Thames are examples.

Waterfalls.—In the past these formed the limit of river navigation. The construction of canals has in many cases overcome this obstacle to navigation; but waterfalls have acquired new importance, in that they often provide electric power for manufacturers. *Minneapolis* on the River Mississippi uses electric power generated from the falls for driving its flour mills.

Crossing Point of Routes.—Where two or more routes cross, the products of different areas come together, and a trade centre is formed to interchange these products. *Cologne* on the Rhine, and *Vienna* on the Danube, are each situated at a crossing point of some of the most important routes of Europe.

Gap Towns.—Many of the most important towns of agricultural England have grown up where a number of routes converge on a natural gap to cross a ridge. *Guildford* on the Wey Gap, and *Canterbury* on the Stour Gap, are only two of many such towns. In Scotland, *Perth*, on the Tay, and *Stirling*, on the Forth, owe their importance to similar natural gaps in the hills.

Junction of Mountain and Plain.—Towns so situated resemble those considered in the preceding paragraph. Mountain ridges can easily be crossed only where the heads of valleys on either side are connected by a pass, or col. Hence on the entrance to such a pass a number of routes from different parts of the plain will converge. *Lucerne* on the north side, and *Milan* on the south side of the St. Gotthard route, are two examples. *Cheyenne* is similarly placed at the base of the Rockies in North America.

Industrial Towns.—All manufactures are due to some source of natural wealth or to some other natural advantage. The growth of steam-power at the beginning of the nineteenth century led to a rapid growth of manufacturing towns in the north and middle of England. In these and other areas what special branch of manufacture was to be carried on in any locality was determined by the presence of local advantages of climate, soil, or other nature. For example, *Sheffield* came to specialise in cutlery, because of the quality of the grindstones quarried in the neighbourhood, also because of certain chemical properties in the waters of the River Don, and because adjacent forests made a constant supply of charcoal available.

EXERCISES

1. Make a list of those towns in your own county which end in "ford" or "bridge," and state the position of each and the river on which it is situated.

2. From a map of England find the chief gap towns in the North and South Downs.

3. Take any region which you have been recently studying,

and name the towns which owe their importance to situation (*a*) at a limit of ocean navigation, (*b*) at a limit of river navigation, (*c*) at a bend on a river, and (*d*) at the confluence of two rivers.

CHAPTER XXXV

TRANSPORT

WE have seen in Chapter XXX, how the people of a district, finding that soil and other conditions favoured the growth of certain crops in their own neighbourhood, began to exchange their surplus products for the different products which an adjacent district could raise more favourably than they could, and how this led to the beginnings of Commerce. Man at that time was content with what he could obtain from his own and from adjacent areas; but, as civilisation has advanced, man's needs have grown enormously, and he now eats and drinks and clothes himself in products drawn from all parts of the world. Thus the means of transport have become increasingly important; and the history of the nineteenth and twentieth centuries tells of the vast improvements that have been made in the carriage of both passengers and goods between one part of the world and another.

Land Transport

Human Porters.—The simplest form of transport is the carriage of goods on the backs of human porters. This method is still in use in China, and also in equatorial regions, where dense vegetation makes travelling difficult, and where the tsetse fly kills off beasts of burden. It is, however, a slow and costly means of transport; and the necessity for its use is being lessened by the construction of motor roads.

Pack Animals.—Much heavier loads than men can bear can be carried by pack animals, which, with goods strapped on their backs, can thread the rough tracks linking two settlements together. The chief pack animals now in use are the mule and camel. In southern Europe, the plateaux of the Andes, and other mountainous areas, mule-transport is still in use where there are no good roads. The camel is still the most reliable means of transport across the desert, though specially-constructed motor-cars and aeroplanes may in the future render unnecessary such a slow method of transport as that by camels.

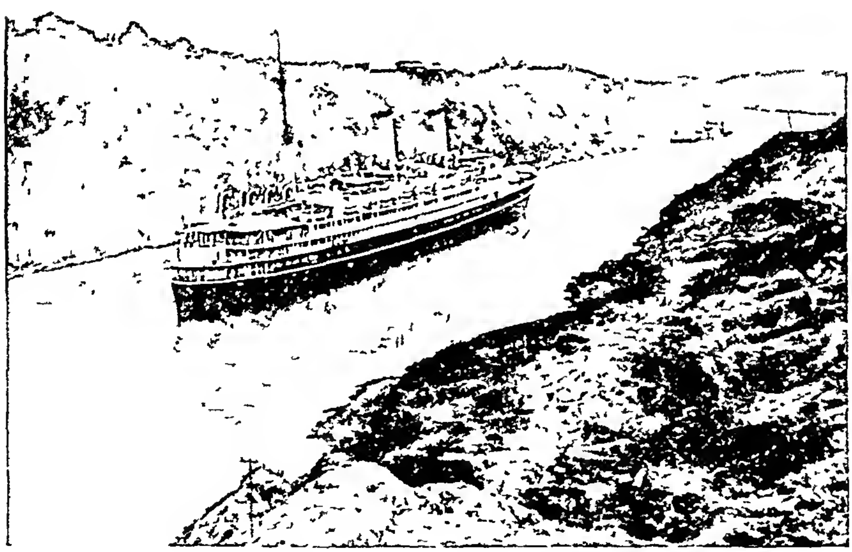
Road Traction.—An animal can pull in a cart a much greater load than it can carry on its back; but even the carriage of goods by horse or ox-drawn vehicles is still very slow and costly. To-day, of course, the use of the motor as a means of conveyance is becoming increasingly important. In tropical lands, and in thinly peopled areas, where the amount of traffic is not sufficiently great to make worth while the heavy expense of constructing railways, motor roads can often be constructed, which by providing links between distant settlements and market towns, allow the development of new areas. In more densely peopled agricultural and industrial regions, goods can be conveyed by motor-lorries, direct from the producer to the consumer.

Railways.—Modern railway engineers can overcome almost all physical barriers. Streams and gorges are bridged; mountains are pierced by tunnels; arms of the sea are crossed by train-ferries. Railways to-day are the chief method of transport in all continents. The east and west coasts of North America are linked up by many trans-continental railroads. From Moscow it is possible to travel to Vladivostok on the Pacific coast of Asia by the Trans-Siberian line, while one can journey from Cairo to Cape Town by means of railway and steamship. Two lines of trans-continental railways even cross the immensely lofty barrier of the Andes in South America.

Navigable Rivers.—Water transport is cheaper than transport by land, because no expense is involved in the upkeep of road or railroad. Navigable rivers are a natural means of transport. In a relatively flat country they can be connected by canals. Transport by river and canal has been highly developed in certain European countries, such as Germany, and forms a slow but inexpensive method of transport for heavy goods, especially where long distances have to be traversed.

Sea Transport

The rapid growth of the size and number of steamships during the last century has increased water trans-



Photo] [*E.N.A.*

FIG. 64.—AN OCEAN STEAMSHIP PASSING THROUGH THE PANAMA CANAL.

port. Sailing vessels, although cheaper to build and maintain, are so slow that they are generally being replaced by steam vessels. Thus modern vessels bring goods from New York to London in less than a week,

and from India in a little over a fortnight. Oil fuel is being increasingly burned in ocean-going vessels as a substitute for coal.

Most modern steamships have cold storage apparatus, and this, by enabling perishable food products to be brought from the other side of the world, has increased the range of our supplies. Fifty years ago our supplies of meat were obtained mainly from home-reared cattle, and butter and cheese, when not made locally, were obtained from nearby countries of Europe. To-day, very large consignments of meat come from Australia, New Zealand, and Argentina, and from the two first we obtain butter and cheese. Similarly, half a century ago, fruit was obtained either locally, or from European countries, whose seasons were the same as our own. To-day, fruit comes from all parts of the world, and we see in our shops all the year round fruits, such as apples, whether or not they happen to be "in season" in European orchards.

Ship Canals.—The development of shipping led to the cutting of great ship canals through land isthmuses in order to shorten routes and save time. The Suez Canal saves a voyage of 2500 miles round Africa on the route to India, and the Panama Canal saves a voyage of 8000 miles round Cape Horn in travelling from New York to San Francisco.

Position of Modern Seaports.—The best natural harbours of the world are the deep rock basins found along mountainous coasts, but these are generally of little use as seaports, because the nature of the coast prevents a convergence of land routes on the port. Hence many of our large modern ports have artificially constructed or deepened harbours. The increase in the size of modern vessels has meant the transfer of trade from some ports once great to others nearer the open sea. Thus Havre has superseded Rouen, and Paulliac has taken the place of Bordeaux.

The essentials of a good modern seaport are:

1. Easy access by road, railway, and canal to a rich interior which has much to export and requires much imported material. The estuary of a river which flows

through a rich manufacturing district or agricultural region generally requires a port at the mouth, rather than farther up the estuary.

2. Close proximity to a main ocean trade route of the globe.

3. Ample docks and ample space for handling and warehousing goods.

4. A deep-water channel giving access to the port, and a sheltered, ice-free harbour, safe under all conditions of wind and tide.

Air Transport

The present century has seen the development of travel by air. Not only do daily services of Air Liners fly between Britain and the chief continental countries, but Air Mail Services, carrying letters and parcels, have been established between Britain and both India and South Africa. A network of air lines covers Central and Western Europe. The next few years will probably see a further development in this method of travel.

The remarkable improvement in all forms of transport has had a very great influence on the progress of civilisation, because peoples in different areas are being brought daily into closer contact with each other, and a closer understanding of each other's problems has resulted. Telegraphs, Cables, and Telephones, which, in the latter part of the last century, made it possible to communicate over long distances, are now being rivalled by modern developments in wireless transmission.

EXERCISES

1. Name the chief modes of transport and the parts of the world in which each is used.
2. What are the conditions which determine the growth of large modern seaports ?
3. Show how modern improvements in sea transport have altered the foods and raw materials obtainable in Great Britain.

CHAPTER XXXVI

PEOPLES AND NATIONS

REMEMBERING what we have learned in the previous chapters of the geographical influences on the distribution of population, and on man's character and occupations, we can understand why the peoples of Western Europe have long been highly civilised and progressive and have been able to carry that civilisation into North America, Australia, and South Africa and other lands where they have settled. These people form the more progressive section of the Aryan race, which is spread over the greater part of Europe, South-Western Asia, India, and Northern Africa. Note how the great Sahara Desert acts as a barrier separating these Aryan peoples from the Negroid races of the remainder of Africa, and that the lofty mountain masses of Central Asia divide them from the Mongolic peoples of South-East and East Asia.

> We can also understand why certain peoples, especially in tropical lands, are backward in civilisation, and are unable to govern themselves and develop their lands to their own best advantage. In these regions European influence should result in the peoples becoming more civilised and able to increase the resources of their countries.

The division of the world into national states has also been influenced by natural conditions. A nation is a political unit consisting of a community of people living generally in a fairly definite region, with natural boundaries, governed by the same laws, in most cases speaking the same language and animated by common ideals and interests. A nation is usually composed of people of the

same race, but may be made up of several races. The size of a national state is often determined by surface relief. On a plain, where the same mode of life is applicable over a wide area, the tendency is for one national state to extend to the limits of the plain. In a mountainous region, a distinctive mode of living, and well-marked local interests and ways of thinking usually prevail, and a small state maintains its independence with the help of natural obstacles to attack offered by the country's relief. While the frontiers of older states, which have become established as the result of centuries of fighting, usually follow natural boundaries, colonial frontiers which have been laid down by agreement between countries before accurate and detailed maps were available, sometimes follow lines of latitude or longitude.

Man's Influence on Nature

It has been shown to what extent man's character, occupations, and distribution over the face of the earth are due to geographical conditions. As, however, man has progressed in knowledge of the processes of Nature and in material resources, he in turn has become increasingly able to influence Nature. Man has irrigated deserts, drained swamps, and transferred the plants and animals of one region to another. He has overcome the barriers offered by mountains, seas, and rivers, and daily is bringing distant lands more closely together in the measurement of time. Into lands with tropical or arctic climates, and amidst conditions widely different from those of his homeland, he has introduced a system of living and standards of conduct which grew up in a temperate continent. That he has been able to do so with a large degree of success in part shows the adaptability of the human race to very varying climatic conditions, in part constitutes a triumph for medical science. It is deeply regrettable that in the process certain native

races have practically died out, as the result either of warfare or of disease, and that the larger animals in some regions of the globe have virtually disappeared.

EXERCISES

1. What natural barriers separate the chief races of mankind ?

2. Name three of the largest and three of the smallest nations of the world. Give any geographical conditions you can to account for their size.

3. In the relationship between man and geographical factors, which dominates the other to-day ? Give reasons for your answer.